THE MEASUREMENT OF PRODUCTIVITY CHANGE AND SOURCES OF GROWTH: THE CASE OF KOREA

By

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Abstract of Dissertation Presented to Graduate School
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THE MEASUREMENT OF PRODUCTIVITY CHANGE AND SOURCES OF GROWTH: THE CASE OF KOREA

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In this dissertation I measure and analyze the productivity change on the supply-side and the sources of growth on the demand-side in the economy of South Korea.

On the supply-side I measure total factor productivity(TFP) of industrial sectors by estimating their translog production functions and value shares simultaneously. In addition to measuring TFP, useful indexes for share elasticities, biases of productivity growth and acceleration of productivity growth are obtained. Share elasticities are used for checking the concavity of the production function, and biases of productivity growth for determining the pattern of production.

On the demand-side, using growth accounting through material balance equations, the increase of output is decomposed into the effect of deviations in domestic demand,

exports, changes in the import structure of intermediate and final goods, and the effect of changes in the matrix of input-output coefficients. The demand-side analysis will yield estimates of the contribution of import substitution and export promotion to the economic growth.

The results indicate that domestic demand and export expansion were the two major factors contributing to growth and structural change. However, import substitution and technological change were quite substantial and much more important than export expansion in the recession period (1979-1981).

In contrast, our results on total factor productivity imply that technical progress played a relatively small role in the industrialization process.

CHAPTER 1
INTRODUCTION

Research Background

Different countries have followed different growth paths, determined partly by initial conditions and resource endowments, and partly by government policies. Some have emphasized import-substitution strategies, others export-promotion strategies. The strategy of encouraging domestic industry by limiting imports of manufactured goods is known as the strategy of import substitution. Another way to promote manufacturing is called an export promotion strategy.[1]

It is known that Korea accomplished rapid growth by export promotion policies during 1962-1978.[2] After having achieved success through export promotion strategies for nearly two decades, Korea encountered severe economic difficulties in 1979-1982, as indicated in Table I-1. What were the cause of this sudden economic recession? It may be

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[1] Krugman, P. R., and M. Obsfeld (1988), pp 229-238.

[2] Corbo, V., A. O. Krueger, and F. Ossa (1985), Ch. 4.
Kim, K. S., and M. Roemer (1979), Ch. 5.
Frank, C. R., K. S. Kim, and L. E. Westphal (1975), Ch. 6.
Westphal, L. E., (1978), pp 347-382.
Krueger, A. O., H. B. Lary, T. Monson, and N. Akrasanee (1981), pp 341-392.

argued that the second oil shock and the subsequent recession in the advanced countries were the major causes. In view of the uninterrupted rapid growth observed in the other Asian Countries of Table I-1, however, domestic factors were also responsible.

Table I-1. GDP Growth Rate at Constant Prices.

Period	Korea	Japan	Thail-land	Sing-apore	Industrial countries	Developing countries
1975	7.5	2.7	7.1	4.1	-0.8	4.7
1976	12.7	4.8	8.7	7.5	5.2	5.5
1977	10.8	5.3	7.2	7.9	3.9	6.1
1978	10.1	5.2	10.1	8.6	4.0	4.3
1979	7.3	5.3	6.1	9.4	3.0	4.7
1980	-3.0	4.3	5.8	10.3	0.6	4.4
1981	6.9	3.7	6.3	9.9	1.5	2.7
1982	5.5	3.1	4.1	6.3	-0.2	1.8
1983	9.5	3.2	5.8	7.9	3.0	0.2
1984	7.9	5.1	6.2	8.1	5.0	2.8
1985	8.2	4.5	4.0	---	3.0	---

Source: IMF, International Financial Statistics, 1986.

But Korea was able to recover from the recession. This phenomenon leads us to some questions: Did Korea continue to pursue the export promotion policies in view of unfavorable external conditions? Which factor on the demand-side was the most important contribution to the growth of output after that recession? How important have export expansion and import substitution been in the process of industrialization? Can we measure total factor productivity (TFP) by using generalized production function instead of the restrictive ones like the Cobb-Douglas or the CES productions function? How can we

characterize the pattern of production on the supply-side? What has been the role of changes in the input-output coefficients? This thesis will attempt to answer these questions through input-output analysis.

Purposes of the Study

In this study I measure and analyze productivity change and the sources of growth in South Korea's manufacturing sector. Specifically I follow two complementary approaches. One is to measure total factor productivity in manufacturing and test restrictions usually imposed on production functions. The other is to measure the contributions of the various components of intermediate and final demand to growth and structural change.

In order to retain flexibility in production functions for the manufacturing sectors in Korea, I adopt the transcendental logarithmic(translog) production functions for the first time rather than more restrictive ones such as Cobb-Douglas or CES production function so that I can test assumptions such as constant return to scale, Hicks neutrality, the concavity of production function, and the existence of value-added.

Total factor productivity for the same manufacturing sectors in Korea has been measured by growth accounting which

is based on the assumption of Hicks neutrality.[3] Later on we will compare our measurement of TFP to what others have measured for the same sectors in Korean manufacturing.

The estimation of total factor productivity(TFP) will be based on gross output, capital, labor, intermediate input and time. In addition to measuring TFP and testing the restrictions which are imposed by the theory of production, we can get some useful indexes for share elasticities, biases of productivity growth and acceleration of productivity growth in estimating the translog production function. On the demand-side, the contributions of the various components of intermediate and final demand to the growth and structural change can be estimated. Changes in the composition of demand are useful in providing an understanding of sectoral growth and structural change. Besides, an analysis of demand is needed to answer the question of the relative role of import substition and export promotion in economic growth.

Manufacturing in South Korea is disaggregated according to the classification in the country's input-output table. We first constructed the input and output data for production function by aggregating detailed industrial data into broadly defined industries in accordance with the input-output table. The productivity analysis can be done at both the aggregate and disaggregate levels.

The supply-side analysis indicates that our measurement

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[3] Kim, K. S., and S. Y. Park (1989).

of total factor productivity is different from what others have measured. In the demand-side analysis, the relative contribution of export expansion to growth and structural change has changed according to different method of measurement.

CHAPTER 2
THE MEASUREMENT OF PRODUCTIVITY CHANGE

The Model: the Producer's Behavior

The starting point for our model is a production function for each industrial sector in the manufacturing. Let the production functions for each of the n industrial sectors be given by

$$X_i = F^i(M_i, K_i, L_i, T) \qquad (i=1,2,\ldots,n). \tag{1}$$

where X_i is the output, M_i, K_i, L_i, and T are the intermediate, capital, and labor inputs and time.

Firms are assumed to maximize profits under perfect competition.

Value Shares and Rate of Productivity Growth

The value shares of intermediate, capital, and labor inputs, say V_M^i, V_K^i, V_L^i, in the value of output can be defined by

$$V_M^i = \frac{P_M^i M_i}{q_i X_i} \tag{2}$$

$$V_K^i = \frac{P_K^i K_i}{q_i X_i} \tag{3}$$

$$V_L^i = \frac{P_L^i L_i}{q_i X_i} \qquad (i=1,2,\ldots,n). \tag{4}$$

where q_i, p_M^i, p_K^i, and p_L^i denote the prices of outputs and intermediate, capital, and labor inputs, respectively.

Profit maximization in the market of perfect competition implies the equality between the share of each input in the value of output and the elasticity of output with respect to that input:

$$V_M^i = \frac{\partial ln X_i}{\partial ln M_i}(M_i, K_i, L_i, T) \tag{5}$$

$$V_K^i = \frac{\partial ln X_i}{\partial ln K_i}(M_i, K_i, L_i, T) \tag{6}$$

$$V_L^i = \frac{\partial ln X_i}{\partial ln L_i}(M_i, K_i, L_i, T) \qquad (i=1,2,\ldots,n). \tag{7}$$

These conditions can be obtained from the following procedure. Profits, Π^i, are defined in value terms as

$$\Pi^i = q_i X_i - p_M^i M_i - p_K^i K_i - p_L^i L_i \qquad (i=1,2,\ldots,n). \tag{8}$$

Assuming that producers wish to maximize profits, Π^{i*}, will be defined as:

$$\Pi^{i*} = \max [\Pi^i - \lambda\{X_i - F^i(M_i, K_i, L_i, T)\}] \qquad (i=1,2,\ldots,n). \tag{9}$$

We can differentiate equation (9) with respect to λ, X_i, p_M^i, p_K^i, p_L^i, and T to derive the conditions for profit maximization in perfect competition:

(a) $$\frac{\partial \Pi^{i*}}{\partial \lambda} = -X_i + F^i(M_i, K_i, L_i, T) = 0$$

(b) $$\frac{\partial \Pi^{i*}}{\partial X_i} = q_i - \lambda = 0$$

(c) $$\frac{\partial \Pi^{i*}}{\partial M_i} = -p_M^i + \lambda \frac{\partial F^i}{\partial M_i} = 0$$

(d) $$\frac{\partial \Pi^{i*}}{\partial K_i} = -p_K^i + \lambda \frac{\partial F^i}{\partial K_i} = 0$$

(e) $$\frac{\partial \Pi^{i*}}{\partial K_i} = -p_K^i + \lambda \frac{\partial F^i}{\partial K_i} = 0$$

(f) $$\frac{\partial \Pi^{i*}}{\partial L_i} = -p_L^i + \lambda \frac{\partial F^i}{\partial L_i} = 0$$

Conditions (b) to (f) imply that the value shares of each input equal to the elasticity of output with respect to that input as denoted in equations (5), (6), and (7).

The rate of productivity growth, say V_T^i, for each sector is defined as the rate of growth of output with respect to time, holding intermediate input, capital input, and labor input constant:[1]

$$V_T^i = \frac{\partial \ln X_i}{\partial T}(M_i, K_i, L_i, T) \qquad (i=1,2,\ldots,n). \qquad (10)$$

Share Elasticities and Substitution

Effects on value shares from a change in input are given

[1] Jorgenson, Gollop, and Fraumeni (1987).

by share elasticities.[2] Share elasticities are defined as the derivatives of the value shares with respect to the logarithms of intermediate, capital, and labor inputs:

$$U^i_{MM}=\frac{\partial V^i_M}{\partial \ln M_i}(M_i,K_i,L_i,T), \tag{11}$$

$$U^i_{MK}=\frac{\partial V^i_M}{\partial \ln K_i}(M_i,K_i,L_i,T), \tag{12}$$

$$U^i_{ML}=\frac{\partial V^i_M}{\partial \ln L_i}(M_i,K_i,L_i,T), \tag{13}$$

$$U^i_{KK}=\frac{\partial V^i_K}{\partial \ln K_i}(M_i,K_i,L_i,T), \tag{14}$$

$$U^i_{KL}=\frac{\partial V^i_K}{\partial \ln L_i}(M_i,K_i,L_i,T), \tag{15}$$

$$U^i_{LL}=\frac{\partial V^i_L}{\partial \ln L^i}(M_i,K_i,L_i,T), \qquad (i=1,2,\ldots,n). \tag{16}$$

If we set the elasticity of output with respect to each input equal to the corresponding value share, then we can get the share elasticities with respect to each input by differentiating the production function $\{F^i\}$ logarithmically twice with respect to the logarithms of intermediate, capital, and labor inputs:

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[2] The concept of share elasticities was introduced first by Christenson, Jorgenson, and Lau (1971;1973) and P.A.Samuelson(1973).

$$U_{MM}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln M_i^2}(M_i, K_i, L_i, T) \tag{17}$$

$$U_{MK}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln M_i \partial \ln K_i}(M_i, K_i, L_i, T) \tag{18}$$

$$U_{ML}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln M_i \partial \ln L_i}(M_i, K_i, L_i, T) \tag{19}$$

$$U_{KK}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln K^2}(M_i, K_i, L_i, T) \tag{20}$$

$$U_{KL}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln K_i \partial \ln L_i}(M_i, K_i, L_i, T) \tag{21}$$

$$U_{LL}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln L_i^2}(M_i, K_i, L_i, T) \qquad (i=1,2,\ldots,n). \tag{22}$$

Interchanging the order of differentiation, we can observe that the share elasticities with respect to each input are symmetric.

$$U_{MK}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln M_i \partial \ln K_i}=\frac{\partial^2 \ln X_i}{\partial \ln K_i \partial \ln M_i}=U_{KM}^{i} \tag{23}$$

$$U_{ML}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln M_i \partial \ln L_i}=\frac{\partial^2 \ln X_i}{\partial \ln L_i \partial \ln M_i}=U_{LM}^{i} \tag{24}$$

$$U_{KL}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln K_i \partial \ln L_i}=\frac{\partial^2 \ln X_i}{\partial \ln L_i \partial \ln K_i}=U_{LK}^{i} \tag{25}$$

These relationships hold for all values of intermediate, capital, and labor inputs, and time.

We can analyze the share elasticities to derive implications of patterns of substitution for the relative distribution of the value of output among the three inputs. If a share elasticity is positive, the value share increases with an increase in the quantity of the corresponding input. If a share elasticity is negative, the value share decreases with the increase of the corresponding input. Finally, if a share elasticity is zero, the value share is independent of the quantity.

Biases of productivity growth and Pattern of Production

The concept of Hicks neutrality leads to a definition of biases in terms of factor shares.[3] Hicks' definition is as follows: Technical change is said to be neutral, labor-saving, or labor-using depending on whether, at a constant capital-labor ratio, the marginal rate of substitution stays constant, increases, or decreases. If the marginal rate of substitution is rising, then the labor share is declining. This leads immediately to the following definition of biases.

The biases of productivity growth can be defined as derivatives of the value shares with respect to time:

$$U_{MT}^{i} = \frac{\partial V_{M}^{i}}{\partial T}(M_i, K_i, L_i, T) \qquad (26)$$

[3] Binswanger (1974).

$$U_{KT}^{i}=\frac{\partial V_{K}^{i}}{\partial T}(M_i, K_i, L_i, T) \tag{27}$$

$$U_{LT}^{i}=\frac{\partial V_{L}^{i}}{\partial T}(M_i, K_i, L_i, T) \qquad (i=1,2,\ldots,n). \tag{28}$$

Alternatively, the biases of productivity growth can be defined as derivatives of the rate of productivity growth with respect to the logarithms of intermediate, capital, and labor inputs:

$$U_{TM}^{i}=\frac{\partial v_{T}^{i}}{\partial \ln M_i}(M_i, K_i, L_i, T) \tag{29}$$

$$U_{TK}^{i}=\frac{\partial v_{T}^{i}}{\partial \ln K_i}(M_i, K_i, L_i, T) \tag{30}$$

$$U_{TL}^{i}=\frac{\partial v_{T}^{i}}{\partial \ln L_i}(M_i, K_i, L_i, T) \tag{31}$$

If we set the elasticity of output with respect to each input equal to the corresponding value share and interchange the order of differentiation, we find that the two definitions are equivalent:

$$U_{MT}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln M_i \partial T}=\frac{\partial^2 \ln X_i}{\partial T \partial \ln M_i}=U_{TM}^{i} \tag{32}$$

$$U_{KT}^{i}=\frac{\partial^2 \ln X_i}{\partial \ln K_i \partial T}=\frac{\partial^2 \ln X_i}{\partial T \partial \ln K_i}=U_{TK}^{i} \tag{33}$$

$$U^i_{LT}=\frac{\partial^2 \ln X_i}{\partial \ln L_i \partial T}=\frac{\partial^2 \ln X_i}{\partial T \partial \ln L_i}=U^i_{TL} \qquad (i=1,2,\ldots,n). \tag{34}$$

The implications for the relative distribution of the value of output among the three inputs can be provided by the biases of productivity growth. If a bias is positive, the corresponding value share increases with time. If a bias is negative, the value share decreases with time. Lastly, the value share is independent of time if a bias is zero.

Acceleration of Productivity Growth

Finally, the acceleration of productivity growth can be defined as the derivative of the rate of productivity growth with respect to time, since the logarithmic derivative of the production function is equal to the rate of productivity growth:[4]

$$U^i_{TT}=\frac{\partial^2 \ln X_i}{\partial T^2}=\frac{\partial V^i_T}{\partial T}(M_i, K_i, L_i, T) \qquad (i=1,2,\ldots,n). \tag{35}$$

The biases and the acceleration of productivity growth are independent of the changes of the inputs and time because they are the second-order logarithmic derivatives of the production function with respect to the logarithms of the inputs and time.

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[4] Jorgenson, Gollop, and Fraumeni (1987).

Restrictions based on Producer Theory

We can derive restrictions on share elasticities and biases of productivity growth implied by the producer's theory.

Hicks neutrality

First we derive restrictions which are implied by Hicks neutrality of productivity growth. The production function is Hicks neutral if and only if T is separable from intermediate, capital, and labor inputs, that is,

$$X_i=F^i(G^i(M_i,K_i,L_i),T) \qquad (i=1,2,\ldots,n). \tag{36}$$

From this equation we can derive the restrictions on the biases of productivity growth which are imposed by Hicks neutrality:

$$U^i_{MT}=U^i_{KT}=U^i_{LT}=0 \qquad (i=1,2,\ldots,n). \tag{37}$$

Under Hicks neutrality the rate of productivity growth depends only on the time term.

$$V^i_T=A^i_T+B^i_{TT}T \qquad (i=1,2,\ldots,n). \tag{38}$$

I will test to ascertain whether production functions in Korean manufacturing can be characterized as having Hicks

neutral technological change.

Constant returns to scale

Next we express the assumption for constant return to scale in terms of share elasticities and biases of productivity growth.

First, the sum of the share elasticities for a given value share, defined by the corresponding second-order logarithmic derivatives, is equal to zero under constant return to scale since all the value shares of the production function add up to unity under constant returns to scale.

$$U^i_{MM}+U^i_{MK}+U^i_{ML}=0 \tag{39}$$

$$U^i_{KM}+U^i_{KK}+U^i_{KL}=0 \tag{40}$$

$$U^i_{LM}+U^i_{LK}+U^i_{LL}=0 \qquad (i=1,2,\ldots,n). \tag{41}$$

In addition, the sum of the biases of productivity growth is equal to zero:

$$U^i_{MT}+U^i_{KT}+U^i_{LT}=0 \qquad (i=1,2,\ldots,n). \tag{42}$$

Concavity of production function

We can derive the restrictions for the concavity of the production function in terms of share elasticities.

The share elasticities can be expressed in terms of the second-order partial derivatives of the production $\{F^i\}$ with

respect to the inputs:[5]

$$U_{MM}^{i}=\frac{\partial^2 \ln F^i}{\partial \ln M_i^2}=\frac{M_i^2}{F^i}\frac{\partial^2 F^i}{\partial M_i^2}-V_M^i(V_M^i-1) \tag{43}$$

$$U_{MK}^{i}=\frac{\partial^2 \ln F^i}{\partial \ln M_i \partial \ln K_i}=\frac{M_i K_i}{F^i}\frac{\partial^2 F^i}{\partial M_i \partial K_i}-V_M^i V_K^i \tag{44}$$

$$U_{ML}^{i}=\frac{\partial^2 \ln F^i}{\partial \ln M_i \partial \ln L_i}=\frac{M_i L_i}{F^i}\frac{\partial^2 F^i}{\partial M_i \partial L_i}-V_M^i V_L^i \tag{45}$$

$$U_{KK}^{i}=\frac{\partial^2 \ln F^i}{\partial \ln K_i^2}=\frac{K_i^2}{F^i}\frac{\partial^2 F^i}{\partial K_i^2}-V_K^i(V_K^i-1) \tag{46}$$

$$U_{KL}^{i}=\frac{\partial^2 \ln F^i}{\partial \ln K_i \partial \ln L_i}=\frac{K_i L_i}{F^i}\frac{\partial^2 F^i}{\partial K_i \partial L_i}-V_K^i V_L^i \tag{47}$$

$$U_{LL}^{i}=\frac{\partial^2 \ln F^i}{\partial \ln L_i^2}=\frac{L_i^2}{F^i}\frac{\partial^2 F^i}{\partial L_i^2}-V_L^i(V_L^i-1) \tag{48}$$

where

$$V_M^i=\frac{\partial \ln F^i}{\partial \ln M_i}=\frac{M_i}{F^i}\frac{\partial F^i}{\partial M_i}$$

$$V_K^i=\frac{\partial \ln F^i}{\partial \ln K_i}=\frac{K_i}{F^i}\frac{\partial F^i}{\partial K_i}$$

$$V_L^i=\frac{\partial \ln F^i}{\partial \ln L_i}=\frac{L_i}{F^i}\frac{\partial F^i}{\partial L_i} \qquad (i=1,2,\ldots n).$$

To derive the restrictions for the concavity of production functions, we construct the matrix of share elasticities U

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[5] The relationship between share elasticities and the condition of concavity is represented in Jorgenson (1986). The conditions for concavity in terms of the Cholesky factorization is represented in Lau (1978;1979).

$$U=\begin{bmatrix} U_{MM}^{i} & U_{MK}^{i} & U_{ML}^{i} \\ U_{KM}^{i} & U_{KK}^{i} & U_{KL}^{i} \\ U_{LM}^{i} & U_{KL}^{i} & U_{LL}^{i} \end{bmatrix} \qquad (i=1,2,\ldots,n). \tag{49}$$

And we can express the matrix of share elasticities U^i by the Hessian matrix of second-order partial derivatives of the production functions H, in the form

$$U^{i}=\frac{1}{F^{i}}N^{i}H^{i}N^{i}-v^{i}v^{i\prime}+V^{i} \tag{50}$$

where

$$H^{i}=\begin{bmatrix} F_{MM}^{i} & F_{MK}^{i} & F_{ML}^{i} \\ F_{KM}^{i} & F_{KK}^{i} & F_{KL}^{i} \\ F_{LM}^{i} & F_{LK}^{i} & F_{LL}^{i} \end{bmatrix}$$

$$N^{i}=\begin{bmatrix} M_{i} & 0 & 0 \\ 0 & K_{i} & 0 \\ 0 & 0 & L_{i} \end{bmatrix}$$

$$V^{i}=\begin{bmatrix} v_{M}^{i} & 0 & 0 \\ 0 & v_{K}^{i} & 0 \\ 0 & 0 & v_{L}^{i} \end{bmatrix} \qquad v^{i}=\begin{bmatrix} v_{M}^{i} \\ v_{K}^{i} \\ v_{L}^{i} \end{bmatrix} \qquad (i=1,2,\ldots,n).$$

The Hessian matrix H can be denoted in the form

$$\frac{1}{F^i}N^iH^iN^i=U^i+v^iv^{i\prime}-V^i \qquad (i=1,2,\ldots,n). \tag{51}$$

The Hessian matrix H should be negative semidefinite under the concavity of the production function. Therefore if the production function is concave, then the matrix $\{ U^i + v^iv^i - V^i \}$ is negative semidefinite. Sufficient conditions for the matrix $\{ U^i + v^iv^i - V^i \}$ to be negative semidefinite are that the matrices of share elasticities U are negative semidefinite since the matrices $\{ v^iv^i - V^i \}$ are negative semidefinite for all nonnegative value shares which are greater than zero and less than one.

To check the concavity of the production functions in terms of the matrices $\{ U^i \}$, we can transform the matrix $\{ U^i \}$ in terms of its Cholesky factorization

$$U^i=Q^iD^iQ^{i\prime} \tag{52}$$

where

$$Q^i=\begin{bmatrix} 1 & 0 & 0 \\ q_{21}^i & 1 & 0 \\ q_{31}^i & q_{32}^i & 1 \end{bmatrix} \qquad D^i=\begin{bmatrix} d_1^i & 0 & 0 \\ 0 & d_2^i & 0 \\ 0 & 0 & d_3^i \end{bmatrix} \qquad (i=1,2,\ldots,n).$$

If and only if the diagonal elements $\{d_1, d_2, d_3\}$ of the

matrix D are nonpositive , the matrix U is negative semidefinite. These conditions must holds if production functions are concave.

Existence of value-added function:[6]

Value-added refers to the addition to the value of product at a particular stage of production. All intermediate inputs are netted out of the calculation.

Some researchers have used value-added indices to measure total factor productivity across countries.[7] In order to measure TFP in terms of value-added, a value-added function relating net output to the inputs of capital and labor must exist. For this to be true, capital, labor, and time must be separable from intermediate inputs. If this separability assumption is testable and rejected, we would rather abandon the calculation of value-added TFP.

A value-added function, where three inputs, capital, labor, and time, produce value-added, exists if and only if the production function is separable in capital, labor inputs, and time from intermediate input.

There are two alternative sets of restrictions that are jointly necessary and sufficient for the existence of a value-

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[6] Jorgenson and Lau (1975), Blackorby, Primont, and Russel (1977), and Denny and Fuss (1977).

[7] Jorgenson and Nishimuzu (1978), and Christensen, Cummings, and Jorgenson (1980).

added function. The first set of jointly necessary and sufficient conditions for the existence of a value-added function can be derived by the following procedure.[8]

The production function for each sector can be written in the following form, if the production function is separable in K_i, L_i, and T from M_i:

$$X_i=F^i(G(K_i,L_i,T),M_i) \qquad (i=1,2,\ldots,n). \tag{53}$$

Under this restriction the value shares of capital and labor inputs and the rate of productivity growth are given by

$$V_K^i=\frac{\partial \ln Z_i}{\partial \ln K_i}=\frac{\partial \ln F^i}{\partial \ln G^i}\frac{\partial \ln G^i}{\partial \ln K_i} \tag{54}$$

$$V_L^i=\frac{\partial \ln Z_i}{\partial \ln L_i}=\frac{\partial \ln F^i}{\partial \ln G^i}\frac{\partial \ln G^i}{\partial \ln L_i} \tag{55}$$

$$V_T^i=\frac{\partial \ln Z_i}{\partial \ln T_i}=\frac{\partial \ln F^i}{\partial \ln G^i}\frac{\partial \ln G^i}{\partial \ln T_i} \qquad (i=1,2,\ldots,n). \tag{56}$$

Next if we differentiate logarithmically the above production function twice, first with respect to the logarithm of intermediate input and then with respect to the logarithms of capital, labor, and time, we obtain the second-order logarithmic derivatives as functions of these inputs and time. We express these second-order logarithmic derivatives as

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[8] The methodology for testing separability was originated by Jorgenson and Lau (1975). See also Jorgenson, Gollop and Fraumeni (1987).

follows.

$$U_{MK}^{i}=\frac{\partial^{2} lnX_{i}}{\partial lnM_{i}\partial lnK_{i}}=\frac{\partial^{2} lnX_{i}}{\partial lnM_{i}\partial G}\frac{\partial G}{\partial lnK_{i}}=r^{i}V_{K}^{i} \tag{57}$$

$$U_{ML}^{i}=\frac{\partial^{2} lnX_{i}}{\partial lnM_{i}\partial lnL_{i}}=\frac{\partial^{2} lnX_{i}}{\partial lnM_{i}\partial G}\frac{\partial G}{\partial lnL_{i}}=r^{i}V_{L}^{i} \tag{58}$$

$$U_{MT}^{i}=\frac{\partial^{2} lnX_{i}}{\partial lnM_{i}\partial T}=\frac{\partial^{2} lnX_{i}}{\partial lnM_{i}\partial G}\frac{\partial G}{\partial T}=r^{i}V_{T}^{i} \tag{59}$$

where

$$r^{i}=\frac{\dfrac{\partial^{2}\ln F^{i}}{\partial\ln M_{i}\partial\ln G^{i}}}{\dfrac{\partial\ln F^{i}}{\partial\ln G^{i}}} \qquad (i=1,2,\ldots,n).$$

The necessary condition for the existence of a value-added function is that there is a common factor of proportionality between the two share elasticities and the bias of productivity growth and the corresponding value shares and the rate of productivity growth. The sufficient condition requires that the common factor r^{i} is equal to zero.

The second set of necessary and sufficient conditions for the existence of value-added functions comes from weak separability, since weak separability and the existence of a

consistence aggregate index are equivalent restrictions.[9]

The production function { F^i } is said to be weakly separable if and only if the marginal rate of substitution (MRS) between any two inputs from the input subset { K_i, L_i, T } is independent of the quantities of the intermediate input { M_i }.

$$\frac{\frac{\partial F^i}{\partial K_i}}{\frac{\partial F^i}{\partial L_i}} = \frac{\frac{\partial^2 F^i}{\partial K_i \partial M_i}}{\frac{\partial^2 F^i}{\partial L_i \partial M_i}} \tag{60}$$

$$\frac{\frac{\partial F^i}{\partial K_i}}{\frac{\partial F^i}{\partial T_i}} = \frac{\frac{\partial^2 F^i}{\partial K_i \partial M_i}}{\frac{\partial^2 F^i}{\partial T_i \partial M_i}} \tag{61}$$

$$\frac{\frac{\partial F^i}{\partial L_i}}{\frac{\partial F^i}{\partial T_i}} = \frac{\frac{\partial^2 F^i}{\partial L_i \partial M_i}}{\frac{\partial^2 F^i}{\partial T_i \partial M_i}} \qquad (i=1,2,\ldots,n). \tag{62}$$

These conditions for weak separability can be written in terms of value share and share elasticities.

$$\frac{V_K^i}{V_L^i} = \frac{U_{MK}^i}{U_{ML}^i} \tag{63}$$

$$\frac{V_K^i}{V_T^i} = \frac{U_{MK}^i}{U_{MT}^i} \tag{64}$$

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[9] Berndt and Christensen (1973).

$$\frac{V_L^i}{V_T^i}=\frac{U_{ML}^i}{U_{MT}^i} \qquad (i=1,2,\ldots,n). \tag{65}$$

Econometric Models: Translog Production function

We can specify the production function as the exponential function of second-order Taylor series.[10]

$$\begin{aligned} X_i=\exp[&A_0^i+A_M^i\ln M_i+A_K^i\ln K_i+A_L^i\ln L+A_T^i T \\ &+\frac{1}{2}B_{MM}^i(\ln M_i)^2+B_{MK}^i\ln M_i\ln K_i+B_{ML}^i\ln M_i\ln L_i+B_{MT}^i\ln M_i T \\ &+\frac{1}{2}B_{KK}^i(\ln K_i)^2+B_{KL}^i\ln K_i\ln L_i+B_{KT}^i\ln K_i T \\ &+\frac{1}{2}B_{LL}^i(\ln L_i)^2+B_{LT}^i\ln L_i T \\ &+\frac{1}{2}B_{TT}^i T^2] \end{aligned} \qquad (i=1,2,\ldots,n) \tag{66}$$

The value shares of intermediate, capital, and labor inputs are given by the derivatives of the logarithm of the production function with respect to the logarithms of intermediate, capital, and labor inputs.

$$V_M^i=A_M^i+B_{MM}^i\ln M_i+B_{MK}^i\ln K_i+B_{ML}^i\ln L_i+B_{MT}^i T \tag{67}$$

$$V_K^i=A_K^i+B_{KK}^i\ln M_i+B_{KK}^i\ln K_i+B_{KL}^i\ln L_i+B_{KT}^i T \tag{68}$$

$$V_L^i=A_L^i+B_{ML}^i\ln M_i+B_{LK}^i\ln K_i+B_{LL}^i\ln L_i+B_{LT}^i T \qquad (i=1,2,\ldots,n). \tag{69}$$

The rates of productivity growth are given by the derivatives of logarithm of production function with respect

[10] Christenson, Jorgenson, and Lau (1971;1973).

to time:

$$V_T^i=A_T^i+B_{MT}^i\ln M_i+B_{KT}^i\ln K_i+B_{LT}^i\ln L_i+B_{TT}^i T \qquad (i=1,2,\ldots,n). \tag{70}$$

From this specific form of the production function we can derive the restrictions on the parameters imposed by production theory. First, if we set the inputs equal to unity and time equal to zero, we obtain necessary conditions for the production functions to be increasing:

$$A_M^i \geq 0$$

$$A_K^i \geq 0$$

$$A_L^i \geq 0 \qquad (i=1,2,\ldots,n).$$

From the translog production functions we can derive the restrictions for Hicks neutrality, that is, each input has no bias in technological change:

$$B_{MT}^i=B_{KT}^i=B_{LT}^i=0 \qquad (i=1,2,\ldots,n). \tag{71}$$

Under Hicks neutrality the rate of productivity growth depends only on the time term.

$$V_T^i=A_T^i+B_{TT}^i T \qquad (i=1,2,\ldots,n). \tag{72}$$

The translog production function for an industrial sector is constant return to scale if and only if the parameters satisfy the conditions:

$$A_M^i+A_K^i+A_L^i=1 \tag{73}$$

$$B_{MK}^i+B_{KK}^i+B_{KL}^i=0 \tag{74}$$

$$B_{MM}^i+B_{MK}^i+B_{ML}^i=0 \tag{75}$$

$$B_{ML}^i+B_{KL}^i+B_{LL}^i=0 \tag{76}$$

$$B_{MT}^i+B_{KT}^i+B_{LT}^i=0 \qquad (i=1,2,\ldots,n). \tag{77}$$

We obtain the first set of necessary conditions for the existence of value-added functions from equation (57), (58), and (59). Evaluating these equations where the three inputs are equal to unity and time is equal to zero, we obtain the following restrictions:

$$B_{MK}^i=\rho^i A_K^i \tag{78}$$

$$B_{ML}=\rho^i A_L^i \tag{79}$$

$$B_{MT}^i=\rho^i A_T^i \tag{80}$$

These equations imply that the value shares of capital and labor inputs and the rate of productivity growth are proportional to the corresponding elasticities of the share of capital and labor with respect to intermediate input and the bias of productivity growth with respect to intermediate input.

The sufficient conditions require

$\rho^i=0$.

The second set of restrictions for the existence of value-added functions result from the fact that output is a linear logarithmic function of intermediate input and value-added:

$$X_i=\exp[A_0^i+A_M^i\ln M_i+A_V^i\ln V_i] \qquad (i=1,2,\ldots,n). \tag{81}$$

where

$$A_V^i\ln V_i=A_K^i\ln K_i+A_L^i\ln L_i+A_T^iT$$
$$+\frac{1}{2}B_{KK}^i(\ln K_i)^2+B_{KL}^i\ln K_i\ln L_i+B_{KT}^i\ln K_iT \ .$$

The value shares of capital, and labor and the rate of productivity growth can be expressed as

$$V_K^i=A_V^i\frac{\partial\ln V_i}{\partial\ln K_i} \tag{82}$$

$$V_L^i=A_V^i\frac{\partial\ln V_i}{\partial\ln L_i} \tag{83}$$

$$V_T^i=A_V^i\frac{\partial\ln V_i}{\partial T} \qquad (i=1,2,\ldots,n). \tag{84}$$

If these equations are substituted into equations which are the conditions for weak separability, a second set of restriction are obtained:

$$\frac{A_K^i}{A_L^i}=\frac{B_{MK}^i}{B_{ML}^i} \tag{85}$$

$$\frac{A_K^i}{A_T^i} = \frac{B_{MK}^i}{B_{MT}^i} \tag{86}$$

$$\frac{A_L^i}{A_T^i} = \frac{B_{ML}^i}{B_{MT}^i} \qquad (i=1,2,\ldots,n). \tag{87}$$

Estimation and Hypothesis testing: Full Information Maximum Likelihood (FIML) and Seemingly Unrelated Regression

Since our model of production is a system of equations with cross equation parameter restrictions, it is likely that the disturbances of the individual equations are correlated. If so, the technique of joint estimation gives more efficient estimates than separate regression of each equation.

Jorgenson, Gollop, and Fraumeni estimated the unknown parameters of the translog production function for the industrial sectors in American economy[11]. They formulated the econometric model by combining the first two equations for the value shares with the equations for the rate of productivity growth. They estimated the parameters of the equations for the remaining value shares from estimates of the parameters of the first two value shares, using the restrictions on these parameters given by the assumption of constant returns to scale.

[11] Jorgenson, Gollop, and Fraumeni (1987).

With their method we cannot estimate the parameters $\{A_T^1, B_{TT}^1\}$ in the translog production. In addition to this weakness, we have to assume constant returns to scale in production. Based on these facts, I estimate the system of equations, logX, V_M, V_k, with the method of full information maximum likelihood (FIML) and seemingly unrelated regression (SUR).

The FIML and SUR estimators have identical efficiencies asymptotically for large sample properties. The SUR takes account of the fact that the structural equations may be correlated in cross equation disturbance term and makes use of the covariance matrix of the disturbances among the equations. The asymptotic covariance matrix of the SUR estimator is identical with that of the FIML estimator. In terms of computational ease, the SUR method is simpler than the FIML method, because the latter results in nonlinear equations in unknown parameters that must be solved. With FIML, however, we can use the likelihood ratio test for testing hypotheses.

Regardless of the large sample properties of two estimators, we obtain smaller standard errors with the SUR method than the FIML method for the data of Korean manufacturing. But the TSP software package does not print some test statistics for the SUR method. Therefore we used both methods to estimate the system of equations model and compare the empirical results.

First we started our estimation from the generalized

model and move to increasingly more restricted ones to test the restrictions which are imposed by the production theory. In our model the rates of productivity growth, V_T,can not be observable. Therefore, we computed the rates of productivity growth(TFP) by using the estimated coefficients. One of value shares in estimation is ommitted in order to avoid perfect multicollinearity.

Data Sources

The data for the Korean manufacturing sector were compiled by KIET (Korea Institute for Economics & Technology). They estimate the annual time series data of output as well as the intermediate, capital, and labor inputs for 39 industries of the manufacturing sector from 1963 to 1983. These data are based on the Report on Mining and Manufacturing Survey and Input-output tables. We use the data from 1963 to 1983 because these are the only years for which data are available.

First we aggregated data for 39 industries to 9 more broadly defined industries in accordance with the classification of the input-output tables. These 9 industries are 1.Food, beverages & tobacco, 2.Textiles & leather, 3.Lumber & wood products, 4.Paper, printing & publishing, 5.Chemicals & chemical products, 6.Nonmetallic mineral products, 7.Primary metal manufacturing, 8.Metal products & machinery, and 9.Miscellaneous manufacturing in the

manucturing sector. We then aggregated these data for the aggregate analysis of the whole manufacturing sector.

We will summarize the characteristics of the data which are provided by KIET. The output is calculated by valuing all outputs at the wholesale prices. The capital stock includes the producers' and consumers' durable equipment, residential and nonresidential structures, inventories and land. Labor inputs are obtained by multiplying the yearly average number of workers by the quality index of labor. The output, capital input, and intermediate input which are calculated by using current prices are converted to a constant price.

Empirical Results

I have constructed an econometric model from a production function and value shares for each industries. First I estimated the parameters of the translog production function with and without restrictions by alternative methods of estimation. I then calculated the rates of productivity growth, V_T, by using the estimated parameters.

First we undertake the likelihood ratio test to test constant returns to scale, Hicks neutrality in technical change and the existence of value added function. Next we test Hicks neutrality in technical change and the existence of value-added function maintaining the assumption of constant returns to scale since we obtain more significant results from

Table II-1. Critical values, chi-squared

degrees of freedom	level of significance					
	0.100	0.050	0.025	0.010	0.005	0.001
1	2.71	3.84	6.36	6.63	7.88	10.83
2	4.60	6.00	8.90	9.22	10.60	13.82
3	6.25	7.81	9.35	11.35	12.84	15.67
5	9.25	11.05	14.72	15.10	16.75	20.50

the model with the assumption of constant returns to scale than the model without the assumption of constant returns to scale. The likelihood ratio test statistics for each tests are represented at Table II-2 and II-3.

For the test statistic for Hicks neutrality of technical change, we employ the critical value 11.35 for chisquared with three degrees of freedom at a level of significance of 0.01. At this level of significance, we reject Hicks neutrality for eight industries in Table II-2. We cannot reject Hicks neutrality for miscellaneous manufacturing and the total manufacturing sector. Under Hicks neutrality, productivity growth does not favor any factor. Therefore, the rejection of Hicks neutrality implies that technological change is biased toward some factors.

We next test for constant returns to scale. The constant returns to scale restrictions require five degrees of freedom, so we employ the critical value 15.10 for chis-quared with five degrees of freedom at a level of significance of 0.01.

Table II-2. Test statistics for Constant returns to scale, Hisks neutrality, and the Existence of value-added

Industry	Hypothesis			
	Hicks neutrality	Constant returns to scale	Value-added I	Value-added II
1.Food, beverages & tobacco	25.4099	60.1144	43.2148	228.3696
2.Textiles & leather	47.3477	53.9048	33.3668	137.2213
3.Lumber & wood products	23.2858	33.7527	-31.5031	81.4153
4.Paper, printing & publishing	48.9642	54.8662	33.5702	128.6722
5.Chemicals & chemical products	15.9575	24.4916	115.7244	334.9333
6.Nonmetallic mineral products	14.8515	12.3842	85.2620	-4.6601
7.Primary metal manufacturing	35.9080	34.5589	-24.2119	141.2689
8.Metal products & machinery	39.4010	15.5197	95.0416	245.9385
9.Miscellane-ous manufacturing	8.6594	32.7385	128.3029	39.7803
The total manufacturing	5.5851	15.6301	73.5605	190.5400

Table II-3. Test statistics for Hicks neutrality and the Existence of value-added maintaining the assumption of Constant returns to scale

Industry	Hypothesis		
	Hicks neutrality	Value-added I	Value-added II
1.Food, beverages & tobacco	16.69647	14.01059	10.13010
2.Textiles & leather	8.82013	34.96957	11.22046
3.Lumber & wood products	0.76572	0.87402	0.26984
4.Paper, printing & publishing	27.24649	37.04483	3.61691
5.Chemicals & chemical products	24.76041	40.14688	12.05225
6.Nonmetalic mineral products	39.66202	16.77090	1.15286
7.Primary metal manufacturing	36.20880	35.96268	34.94168
8.Metal products & machinery	48.99066	47.19305	30.75528
9.Miscellane-ous manufacturing	13.89905	10.17068	4.16483
The total manufacturing	0.08569	11.56906	8.70789

Constant return to scale can be rejected at this level of significance for all industries except Nonmetallic mineral products in Table II-2.

Next we test for the existence of a value-added functions. For the test for the existence of a value-added functions, the first set of restrictions require three degrees of freedom, and the second set of restrictions require two degrees of freedom. The critical value 11.35 for the first set of restrictions and 9.22 for the second set of restrictions are employed for the chi-squared at a level of significance of 0.01. The two sets of restrictions for the existence of value-added functions can be rejected at a level of significance of 0.01 for each industry and the total manufacturing sector in Table II-2. Here we obtain negative statistics in the case that the convergence cannot be achieved.

Now we test Hicks neutrality and the existence of value-added function maintaining the assumption of constant returns to scale. Test statistics for three hypotheses are represented in Table II-3. The restrictions to Hicks neutrality require two degrees of freedom, so we employ the critical 9.22 for chi squared with two degrees of freedom at a level of significance of 0.01. Hicks neutrality is not rejected for two industries: Textiles & leather and Lumber & wood products. Hicks neutrality is not rejected for the total manucturing either.

The first set of restrictions to the existence of a value-added function maintaining the assumption of constant

returns to scale requires two degrees of freedom, so the critical value 9.22 is employed for chi-squared with two degrees of freedom at a level of significance of 0.01. The hypothesis that the production function is separable in K_i, L_i, and T from M_i cannot be rejected for one industry: Lumber & wood products in Table II-3. For the second set of restrictions to the existence of value-added function, we employ the critical value 6.63 for chi-squared with one degree of freedom at a level of significance of 0.01. We cannot reject the hypothesis that output is a linear logarithmic function of intermediate input and value-added at a level of significance of 0.01 for four industries: Lumber & wood products, Paper, printing & publishing, Nonmetallic mineral products, and Miscellaneous manufacturing in Table II-3. The rejection of the hypothesis that a value-added function exists implies that we would rather abandon measuring TFP from value-added.

We evaluate estimates in the same model which are estimated by different methods of estimation (FIML and SUR). These estimates are presented in Table II-4 and Tables II-14 to II-19, which are given in the appendix. We obtain smaller standard error with the SUR method than with the FIML method. In addition to significance, convergence is achieved more easily by SUR than by FIML. For large sample properties, however, we cannot conclude that SUR provides more efficient estimates than FIML, and convergence is achieved more easily

by SUR than by FIML.

Let us compare the estimates under different assumptions by SUR. The model under constant return to scale provides more efficient estimates than the one under the other assumptions: Hicks neutrality and existence of value-added function.

So far we have evaluated and compared the estimates based on econometric properties. Now we evaluate estimates based on the production theory in order to see which model describes the Korean economy best and in order to measure TFP correctly.

If we check the necessary conditions for monotonicity by examining estimated parameters { A_M^i, A_K^i, A_L^i } in Table II-4 and Table II-15 to II-20 in the appendix, we find that models under constant return to scale which are estimated by SUR satisfy these conditions since the estimated parameters { A_M^i, A_K^i, A_L^i } are all significantly positive in Table II-4.

To check the concavity of the production functions, the diagonal matrix in the Cholesky factorization of the matrix of share elasticities is illustrated in Table II-8 given in appendix. We check the condition of the concavity for the sector's production function under the different restrictions. By the method of FIML, the concavity of the production function can be accepted for two industries in the generalized model, while this condition can be guaranteed for five industries in the model restricted to constant returns to scale. Similarly by the method of SUR the condition of concavity of production function can be guaranteed for four

industries in the model restricted by constant returns to scale. For Nonmetalic mineral products and Metal products & machinery, constant returns to scale can be guaranted by both methods. Constant returns to scale is a special case of production function, given convex isoquants. Therefore the condition for the concavity of production function is well guaranteed by the assumption of constant returns to scale.

Based on statistical significance of estimates and production theory, we obtain the best results from the model restricted to constant returns to scale by the estimation method of SUR. Now we interpret the parameter estimates which are represented in Table II-4.

The estimated share elasticities (B_{MM}^{i}, B_{MK}^{i}, B_{ML}^{i}, B_{KK}^{i}, B_{KL}^{i}, B_{LL}^{i}) provide the implications of patterns of substitution for the relative distribution of the value of output among intermediate, capital, and labor inputs. If share elasticities are positive, then the value shares increase with an increase of the corresponding input; if share elasticities are negative, the value shares decrease with an increase of the input; if share elasticities are equal to zero, value shares are independent of the change of input.

Under the necessary and sufficient conditions for concavity of the production function for each sector, the estimated share elasticities of each input with respect to the quantity of the input itself (B_{MM}^{i}, B_{KK}^{i}, B_{LL}^{i}) are nonpositive. This implies that the share of each input is not

Table II-4. Parameter Estimates under Constant Return to Scale by SUR

Parameter	Industry		
	1.Food, beverages & tobacco	2.Textiles & leather	3.Lumber & wood products
A^i_O	-0.4167	-0.1380	-0.2665
	(-21.7500)	(-2.4045)	(-6.4856)
A^i_K	0.4026	0.2098	0.0840
	(21.9890)	(4.5973)	(2.2548)
A^i_L	0.0983	0.1544	0.1531
	(7.1444)	(9.4574)	(11.2560)
A^i_M	0.4990	0.6356	0.7628
	(21.0140)	(13.9630)	(26.7960)
A^i_T	0.0365	0.0071	0.0371
	(9.2268)	(0.6114)	(4.6655)
B^i_{MM}	-0.0617	-0.0034	0.1060
	(-1.6493)	(-0.0746)	(4.0230)
B^i_{MK}	0.0669	0.0102	-0.1114
	(2.8338)	(0.2359)	(-3.1315)
B^i_{ML}	-0.0052	-0.0067	0.0054
	(-0.2221)	(-0.4109)	(0.4109)
B^i_{MT}	0.0033	0.0053	-0.0020
	(1.4533)	(1.3947)	(-0.9673)
B^i_{KK}	-0.0413	-0.0309	0.1359
	(-1.7225)	(-0.6722)	(2.5645)
B^i_{KL}	-0.0255	0.0207	-0.0245
	(-2.0003)	(1.2430)	(-1.1029)
B^i_{KT}	-0.0015	-0.0049	0.0026
	(-0.8255)	(-1.2939)	(0.9259)
B^i_{LL}	0.0307	-0.0139	0.0191
	(1.7032)	(-1.1575)	(1.6262)
B^i_{LT}	-0.0018	-0.0004	-0.0005
	(-1.3941)	(-0.3070)	(-0.5470)
B^i_{TT}	0.0002	0.0009	-0.0020
	(0.7561)	(0.9661)	(-3.0137)

Parameter	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
A^i_O	-0.0810	-0.7670	-0.4109
	(-4.9685)	(-7.4796)	(-13.7140)
A^i_K	0.1658	0.2544	0.3098
	(26.2230)	(9.7568)	(18.4240)
A^i_L	0.1913	0.1102	0.1709
	(39.1810)	(11.8330)	(18.5460)
A^i_M	0.6427	0.6352	0.5192
	(119.9600)	(20.1130)	(27.9110)
A^i_T	0.0006	0.1078	0.0454
	(0.1786)	(5.0653)	(7.6512)
B^i_{MM}	-0.0069	-0.0719	-0.0186
	(-0.5632)	(-2.4548)	(-0.8351)
B^i_{MK}	-0.0065	0.0684	0.0151
	(-0.6684)	(2.8826)	(0.9403)
B^i_{ML}	0.0135	0.0034	0.0034
	(0.9366)	(0.4274)	(0.3376)
B^i_{MT}	0.0030	0.0102	0.0066
	(5.7375)	(3.4811)	(4.6585)
B^i_{KK}	-0.0076	-0.0405	-0.0557
	(-0.5889)	(-1.5005)	(-3.7295)
B^i_{KL}	0.0142	-0.0278	0.0405
	(1.1586)	(-1.7119)	(5.0015)
B^i_{KT}	-0.0026	-0.0083	-0.0082
	(-4.0810)	(-3.3897)	(-6.4241)
B^i_{LL}	-0.0277	0.0243	-0.0440
	(-1.2636)	(1.9440)	(-6.0016)
B^i_{LT}	-0.0003	-0.0018	0.0015
	(-0.8100)	(-1.9786)	(2.2123)
B^i_{TT}	0.0011	-0.0091	-0.0017
	(3.8449)	(-4.7856)	(-3.3756)

Parameter	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
A^i_O	-0.3587	-0.3898	-0.2993
	(-9.9276)	(-11.5760)	(-10.1830)
A^i_K	0.1339	0.3365	0.2209
	(3.0703)	(13.0700)	(8.1721)
A^i_L	0.0459	0.0865	0.1534
	(3.5713)	(6.3743)	(17.4260)
A^i_M	0.8201	0.5769	0.6256
	(19.7180)	(16.0220)	(26.3610)
A^i_T	0.0366	0.0446	0.0273
	(5.9726)	(6.8688)	(4.6190)
B^i_{MM}	0.0668	-0.1490	0.0006
	(2.3428)	(-4.1882)	(0.0167)
B^i_{MK}	-0.0388	0.1473	-0.0093
	(-1.3621)	(5.9170)	(-0.2850)
B^i_{ML}	-0.0280	0.0016	0.0087
	(-3.2416)	(0.1194)	(0.7409)
B^i_{MT}	-0.0020	0.0189	0.0028
	(-0.6223)	(5.7329)	(0.9592)
B^i_{KK}	-0.0045	-0.1814	-0.0077
	(-0.1464)	(-9.4625)	(-0.2523)
B^i_{KL}	0.0433	0.0341	0.0171
	(4.6146)	(3.4866)	(1.7552)
B^i_{KT}	-0.0009	-0.0187	-0.0036
	(-0.2603)	(-7.8888)	(-1.3696)
B^i_{LL}	-0.0153	-0.0357	-0.0258
	(-2.9489)	(-4.0535)	(-3.0274)
B^i_{LT}	0.0029	-0.0002	0.0007
	(2.8327)	(-0.1628)	(0.9121)
B^i_{TT}	-0.0013	-0.0019	-0.0002
	(-2.7374)	(-3.3505)	(-0.4300)

Parameter	Industry The total manucturing
A^i_O	-0.3607
	(-12.3520)
A^i_K	0.1930
	(24.7250)
A^i_L	0.1086
	(15.1540)
A^i_M	0.6983
	(87.9140)
A^i_T	0.0407
	(6.7934)
B^i_{MM}	0.0662
	(5.7552)
B^i_{MK}	-0.0144
	(-1.1453)
B^i_{ML}	-0.0517
	(-7.4077)
B^i_{MT}	-0.0020
	(-3.0507)
B^i_{KK}	-0.0063
	(-0.4107)
B^i_{KL}	0.0208
	(3.1875)
B^i_{KT}	-0.0006
	(-0.9923)
B^i_{LL}	0.0309
	(3.2534)
B^i_{LT}	0.0027
	(3.9595)
B^i_{TT}	-0.0020
	(-3.9515)

increasing with the increase of the input itself.

The estimated elasticities of the share of intermediate input with respect to the quantity of the input itself (B_{MM}^i) are significantly negative for Chemicals & chemical products and Metal products & machinery. The estimated elasticities of the share of capital input with respect to the input itself (B_{KK}^i) are significantly negative for Nonmetalic mineral products and Metal products & machinery. The estimated elasticities of the share of capital input with respect to the input itself (B_{LL}^i) are significantly negative for Nonmetalic mineral products, Primary metal manufacturing, Metal products & machinery, and Miscellaneous manufacturing.

The estimated elasticities of the share of labor with respect to the quantity of capital (B_{KL}^i) are significantly positive for Nonmetalic mineral products, Primary metal manufacturing, Metal products & machinery, and The total manufacturing. For these industries, the share of labor does not decrease with an increase in the quantity of capital, holding quantities of labor and intermediate inputs and time constant. Of course, this parameter can also be interpreted as the elasticities of the share of capital with respect to the quantity of labor, so the share of capital does not decrease with an increase in the quantity of labor. Meanwhile, the estimated elasticity of the share of labor with respect to the quantity of capital is significantly negative for Food beverages & tobacco.

The estimated elasticities of the share of intermediate input with respect to the quantity of capital (B_{MK}^{i}) are significantly positive for Food beverages & tobacco, Chemicals & chemical products, and Metal products & machinery, and significantly negative for Lumber & wood products on the other hand. This parameter can also be interpreted as the elasticity of the share of capital with respect to the quantity of intermediate input.

The estimated elasticities of the share of intermediate input with respect to the quantity of labor (B_{ML}^{i}) are significantly negative for Primary metal manucturing, and The total manufacturing. For the other industries, the estimated parameters for elasticities of the share of intermediate input with respect to the quantity of labor are not significant.

The estimated biases of productivity growth ($B_{MT}^{i}, B_{KT}^{i}, B_{LT}^{i}$) can be considered as the change in the share of each input with respect to time, holding all inputs constant. Also the biases of productivity growth can be interpreted as changes in the rate of productivity growth with respect to proportional changes in input quantities. For example, if the bias with respect to labor input (B_{LT}^{i}) is positive,the rate of productivity growth increases with the increase of the labor input. If the bias is negative, the productivity growth decreases with the increase of the labor input. We derive the following interpretations about biases of productivity growth based on Binswanger's concept of biases of productivity

growth.[12] If the estimated value of the bias of productivity growth with respect to intermediate input is positive (B_{MT}^{i}), productivity growth is intermediate-using; if the value is negative, productivity growth is intermediate-saving. In the same way the estimated value of the biases of productivity growth with respect to capital input and labor input (B_{KT}^{i}, B_{LT}^{i}) implies capital-using or capital-saving, and labor-using or labor-saving. All the industries can be classified by their patterns of the biases of productivity. If we assume constant returns to scale in production, we can rule out the possibility that the three biases are either all negative or all positive.

A classification of industries by their patterns of biases of productivity growth is represented in Table II-5. The different estimation methods (FIML and SUR) provide different estimates of biases of productivity growth. FIML estimation shows in Table II-15 given in appendix that most of estimated biases of productivity growth are not significant. However, SUR estimation represented in Table II-4 shows that more estimated coefficients for biases of productivity growth are significant. Therefore we use the results from the SUR method to classify industries according to the biases of productivity growth. Here we eliminate two industries, Textiles & leather and Lumber & wood products, and the total

[12] Binswanger (1974).

Table II-5. Classification of Industries by Biases of Productivity Growth under Constant Returns to Scale by SUR

Pattern of biases	Industries
Intermediate-using Capital-saving Labor-saving	Food, beverages & tobacco Paper, printing & publishing Chemicals & chemical products Metal products & machinery
Intermediate-using Capital-saving Labor-using	Nonmetalic mineral products Miscellaneous manufacturing
Intermediate-using Capital-using Labor-saving	
Intermediate-saving Capital-saving Labor-using	Primary metal manufacturing
Intermediate-saving Capital-using Labor-using	
Intermediate-saving Capital-using Labor-saving	

manufacturing in classifying industries according to the biases of productivity growth since Hicks neutrality cannot be rejected at a level of significance of 0.01 for these industries and the total manufacturing. The pattern which occurs with greatest frequency in Table II-5 is intermediate-using, capital-saving, and labor-saving. This pattern characterizes four industries. Meanwhile, the patterns that occur most frequently in the classification of industries which is given by Jorgenson, Gollop, and Fraumeni(1987) are intermediate-using and labor-saving in combination with capital-using and capital-saving.

An alternative interpretation of biases of productivity growth is that they represent changes in the rate of productivity growth with respect to proportional changes in input quantities. The rate of productivity growth increases with the increase of corresponding input if the bias of productivity growth is positive. The rate of productivity growth increases in the quantity of intermediate input for six of the nine industries and decreases for one in Table II-5. The rate of productivity growth decreases in the quantities of capital for seven industries. This fact raises us doubt about the role of capital accumulation which traditional growth theory emphasizes in the development processes of developing countries. The rate of productivity growth decreases in the quantities of labor for four industries.

Finally, let us examine the TFP's in Table II-6 and Table

Table II-6. Total Factor Productivity under Constant Return to Scale by SUR

Year	Industry		
	1. Food, beverages & tobacco	2. Textiles & leather	3. Lumber & wood products
1963	0.03517	0.00428	0.03724
1964	0.03559	0.00602	0.03460
1965	0.03594	0.00704	0.03243
1966	0.03632	0.00531	0.03031
1967	0.03680	0.00911	0.02835
1968	0.03728	0.01018	0.02633
1969	0.03771	0.01126	0.02412
1970	0.03811	0.01281	0.02144
1971	0.03858	0.01431	0.01909
1972	0.03906	0.01645	0.01635
1973	0.03949	0.01807	0.01430
1974	0.03993	0.01982	0.01208
1975	0.04043	0.02131	0.01006
1976	0.04099	0.02263	0.00768
1977	0.04155	0.02395	0.00538
1978	0.04204	0.02506	0.00332
1979	0.04245	0.02639	0.00138
1980	0.04284	0.02772	-0.00060
1981	0.04330	0.02899	-0.00285
1982	0.04383	0.03013	-0.00525
1983	0.04425	0.03176	-0.00747
mean	0.03960	0.01774	0.01468

Year	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
1963	0.00117	0.08758	0.03479
1964	0.00222	0.07962	0.03427
1965	0.00331	0.07249	0.03342
1966	0.00434	0.06492	0.03198
1967	0.00544	0.05710	0.03004
1968	0.00657	0.04944	0.02890
1969	0.00784	0.04095	0.02812
1970	0.00920	0.03252	0.02793
1971	0.01053	0.02425	0.02728
1972	0.01200	0.01659	0.02701
1973	0.01336	0.00757	0.02620
1974	0.01464	0.00451	0.02488
1975	0.01588	-0.00496	0.02346
1976	0.01727	-0.01360	0.02251
1977	0.01871	-0.02201	0.02139
1978	0.02014	-0.03090	0.01986
1979	0.02150	-0.04015	0.01804
1980	0.02297	-0.04987	0.01638
1981	0.02442	-0.05938	0.01492
1982	0.02593	-0.06874	0.01391
1983	0.02734	-0.07695	0.01296
mean	0.01356	0.00814	0.02468

Year	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
1963	0.03723	0.02410	0.02571
1964	0.03550	0.02445	0.02521
1965	0.03390	0.02554	0.02489
1966	0.03217	0.02522	0.02463
1967	0.03031	0.02478	0.02479
1968	0.02842	0.02423	0.02495
1969	0.02702	0.02307	0.02523
1970	0.02571	0.02151	0.02505
1971	0.02430	0.02012	0.02485
1972	0.02263	0.02163	0.02480
1973	0.02132	0.02353	0.02484
1974	0.02031	0.02380	0.02489
1975	0.01920	0.02450	0.02501
1976	0.01803	0.02494	0.02514
1977	0.01664	0.02687	0.02536
1978	0.01540	0.02690	0.02548
1979	0.01427	0.02564	0.02559
1980	0.01313	0.02454	0.02583
1981	0.01195	0.02398	0.02584
1982	0.01062	0.02485	0.02584
1983	0.00922	0.02557	0.02580
mean	0.02225	0.02427	0.02523

Year	Industry The total manucturing
1963	0.04036
1964	0.03812
1965	0.03590
1966	0.03389
1967	0.03150
1968	0.02925
1969	0.02702
1970	0.02471
1971	0.02244
1972	0.02001
1973	0.01774
1974	0.01515
1975	0.01295
1976	0.01068
1977	0.00835
1978	0.00607
1979	0.00379
1980	0.00151
1981	-0.00077
1982	-0.00307
1983	-0.00531
mean	0.01763

II-9 to II-14 in appendix which are calculated by using the estimated coefficients in the different models. The TFP from the generalized model fluctuates highly. However, the TFP from the models under constant returns to scale by the estimation method of SUR show the similar result with the one from the model under constant returns to scale by FIML. TFP's from the model under constant returns to scale which is estimated by SUR show a deceleration of productivity growth, that is, the estimated accelerations of productivity growth (B_{TT}^{i}) are significantly negative for five industries. Also TFP for the total manufacturing exhibits a deceleration of productivity growth.

Now we compare our measurement of TFP to what others have measured. Kim and Park have measured TFP for the same sectors in Korean manufacturing based on the methodology of growth accounting. The growth accounting was introduced by Solow (1957) and has been discussed by Hulten (1973), Jorgenson and Griliches (1967,1971). I explain their methodology briefly in terms of the same notations in our model. The growth accounting equation starts from a production function:

$$X_i = F^i(M_i, K_i, L_i, T) \qquad (i=1,2,\ldots,n). \qquad (1)$$

TFP in growth accounting is defined as rate of growth of output with respect to time, holding intermediate, capital, and labor inputs constant:

$$V_T^i = \frac{\partial \ln X_i}{\partial T}(M_i, K_i, L_i, T) \qquad (i=1,2,\ldots,n). \qquad (10)$$

Under constant returns to scale, the rate of technical change for each sector can be expressed as the rate of growth of the corresponding sectoral output less a weighted average of the rates of growth of intermediate input, capital input, and labor input, where the weights are given by the corresponding value shares:

$$\begin{aligned}\frac{d\ln X_i}{dT} &= \frac{\partial \ln X_i}{\partial \ln M_i}\frac{d\ln M_i}{dT} + \frac{\partial X_i}{\partial \ln K_i}\frac{d\ln K_i}{dT} \\ &+ \frac{\partial \ln X_i}{\partial \ln L_i}\frac{d\ln L_i}{dT} + \frac{\partial \ln X_i}{\partial T} \qquad . \quad (i=1,2,\ldots,n) \\ &= V_M^i \frac{d\ln M_i}{dT} + V_K^i \frac{d\ln K_i}{dT} + V_L^i \frac{\ln L_i}{dT} \\ &+ V_T^i\end{aligned}$$

The comparisons of TFP's measured by different methods are represented in Table II-7. TFP's measured by growth accounting are greater than TFP's measured by translog production function for five of nine industries and the total industries, and less for the other. Since TFP measured by growth accounting is based on the assumption of Hicks neutrality, it cannot explain the effect of bias of

Table II-7. Comparison of TFP's measured by different methods: growth accounting and translog production function

Industry	TFP measured by growth accounting	TFP measured by translog production function
1.Food, beverages & tobacco	0.0231	0.0396
2.Textiles & leather	0.0201	0.0177
3.Lumber & wood products	0.0239	0.0146
4.Paper, printing & publishing	0.0223	0.0135
5.Chemicals & chemical products	0.0016	0.0081
6.Nonmetalic mineral products	0.0191	0.0246
7.Primary metal manufacturing	0.0180	0.0225
8.Metal products & machinery	0.0374	0.0242
9.Miscellane-ous manufacturing	0.0318	0.0252
The total manufacturing	0.0208	0.0176

productivity growth on TFP. However, TFP measured by translog production function reflects the effect of bias of productivity growth as denoted in equation

$$V_T^i = A_T^i + B_{MT}^i \ln M_i + B_{KT}^i \ln K_i + B_{LT}^i \ln L_i + B_{TT}^i T \qquad (i=1,2,\ldots,n). \qquad (70)$$

If we assume Hicks neutrality in our flexible model, the rate of productivity growth is determined as denoted in equation

$$V_T^i = A_T^i + B_{TT}^i T \qquad (i=1,2,\ldots,n). \qquad (72)$$

It is known that the Korean economy accomplished the rapid growth during the last two decades. However, our estimation of TFP's implies that the outstanding characteristic of the Korean economy is the decelerating TFP. The industrialization of the Korean economy is not due to technological progress. If we observe the normalized variables of X, L, K, and M in data set, the intermediate input is the fastest growing input. In this observation, we can conclude that much of the industrialization in Korea is attributable to the growth of the intermediate input.

CHAPTER 3
THE MEASUREMENT OF SOURCES OF GROWTH

The Model: Input-Output Analysis

The starting point for measuring contributions of demand-side factors to growth is the material balance equation of input-output analysis. The input-output model can be used as a tool to disentangle the relative contributions to growth and structural change of different components of changes in the final demand.

The material balance equations for the supply of and the demand for domestically produced goods can be written as

$$X_t = A_t X_t + F_t + E_t - M_t \tag{88}$$

where X_t = domestic production vector in year t

A_t = input-output coefficients matrix such that A_{ij} is composite intermediate demand of sector i per unit of domestic output in sector j in year t

$A_t X_t$ = intermediate demand vector in year t (composite of imported and domestic goods)

F_t = domestic final demand vector in year t (composite of imported and domestic goods)

E_t = export vector of domestic goods in year t

M_t = import vector in year t.

The problem with the definition of the above variables is

how to treat imports. Imports can be classified as either competitive or as noncompetitive. If they are noncompetitive, then they are not grouped with domestic products but are viewed as a nonproduced input into a sector, analogous to labor and capital. But in this model, I regarded all imports as competitive so that they are included in the same sector classification as domestic production.

Let's assume that the ratio of domestic demand for domestically produced goods to total domestic demand is fixed by sectors. These domestic demand ratios in year t are given by

$$d_{i,t}=\frac{X_{i,t}-E_{i,t}}{F_{i,t}+V_{i,t}} \tag{89}$$

where $V_t = A_t X_t$.

Defining a diagonal Matrix D_t of the d_i parameters, the material balance equation for domestic goods is given by

$$X_t=D_tV_t+D_tF_t+E_t \tag{90}$$

This equation can be derived by the following procedure. Let's consider the ith row in the material balance equation.

$$X_{it}=V_{it}+F_{it}+E_{it}-M_{it} \tag{91}$$

We express this equation in terms of the domestic demand ratio as follows.

$$X_{it} = (1 - \frac{M_{it}}{V_{it}+F_{it}}) (V_{it}+F_{it}) + E_{it}$$

$$= d_{it}(V_{it}+F_{it}) + E_{it} \qquad (92)$$

If we diagonalize d_i, and vectorize the other variables, then we can get the matrix expression of equation (93).

$$X_t = D_t(V_t+F_t) + E_t \qquad (93)$$

Noting that $V_t = A_t X_t$, the material balance equation can be written as

$$X_t = (I-D_t A_t)^{-1}(D_t F_t + E_t) \quad . \qquad (94)$$

The production of output X_t is determined by the domestic final demand F_t and exports E_t according to this expression of the material balance equation. The demand-side growth accounting can be established by using this equation. As will be explained, there are two methods of decomposing the sources of growth. One is the method based on absolute growth, and the other is the method based on proportional growth.

Decomposition of Output Growth based on Absolute Growth

Syrquin formulated the method in terms of absolute change in output and used it for the decomposition of industrial output growth. Kubo and Robinson reformulated the Syrquin

Method.[1]

Denoting the change in a variable between two periods by Δ [$\Delta X_t = X_t - X_{t-1}$] , the change in sectoral output can be written (after some algebraic manipulation) as shown below

$$\Delta X_t = R_{t-1} D_{t-1} (\Delta F_t) \quad \text{(a)}$$

$$+ R_{t-1} (\Delta F_t) \quad \text{(b)}$$

$$+ R_{t-1} (\Delta D_t) (F_t + V_t) \quad \text{(c)}$$

$$+ R_{t-1} D_{t-1} (\Delta A_t) X_t \quad \text{(d)} \qquad (95)$$

(a) Effects of domestic changes in domestic demand in all sectors(DD),

(b) Effects of changes in exports in all sectors (EE),

(c) Effects of changes in the import structure of intermediate and final goods (IS),

(d) Effects of changes in the matrix of input-output coefficients (IO).

The above decomposition equation can be derived from equation (94). If we denote $R_t = (I - D_t A_t)^{-1}$, then equation (94) can be written as

$$X_t = R_t (D_t F_t + E_t) \qquad (96)$$

Let's take the first difference from this equation, then we obtain

$$\Delta X_t = R_{t-1} (D_{t-1} \Delta F_t + \Delta E_t + \Delta D_t F_{t-1}) + \Delta R_t (D_{t-1} F_{t-1} + E_{t-1}) \quad . \qquad (97)$$

---

[1] Dervis, K., J. D. Melo, and S. Robinson (1982). pp92-110.

The first difference of an inverse matrix is given by

$$\begin{aligned}\Delta R_t &= \Delta [I - D_t A_t]^{-1} \\ &= -R_t \Delta (I - D_t A_t) R_t \\ &= R_{t-1} (\Delta D_t A_{t-1} + D_{t-1} \Delta A_t) R_{t-1} \end{aligned} \quad (98)$$

Substituting this equation into the above equation, we get the decomposition equation (95)

$$\Delta X_t = R_{t-1} D_{t-1} (\Delta F_t) + R_{t-1} (\Delta E_t) + R_{t-1} (\Delta D_t) (F_{t-1} + V_{t-1}) + R_{t-1} D_{t-1} (\Delta A_t) X_{t-1} \ .$$

This equation gives the basic decomposition of the change in sectoral output into different sources (i.e., ΔF_t, ΔE_t, ΔD_t, and ΔA_t). The first two terms on the right-hand side of the above equation are changes in the output of sector *i* induced by the expansion of domestic demand and exports in all sectors, given a constant import structure. The third and fourth terms measure the direct and indirect effects of changes in the import structure of final and of intermediate goods. The last term gives the direct and indirect effects of changes in the total (domestic and imported) matrix of input-output coefficients, which represent the widening and deepening of interindustry relations brought about by the changing mix of intermediate input requirements. The changes in input-output coefficients are caused, in turn, by changes in production technology as well as by substitution among

various inputs (perhaps in response to changes in relative prices), although we cannot separate these two effects without more information.

Decomposition of Output Growth based on Proportional Growth

Chenery provided the decomposition method by using the differences which are called the "deviations from proportional expansion".[2] Let's define the deviation from proportional growth of output of sector *i* as $\delta X_{it} = X_{it} - \lambda X_{i,t-1}$, *where* λ *is the ratio of GNP in period t to GNP income in period t-1.*

$$\delta X_{it} = X_{it} - \lambda X_{i,t-1}$$

$$\delta F_{it} = F_{it} - \lambda F_{i,t-1}$$

$$\delta V_{it} = V_{it} - \lambda V_{i,t-1}$$

$$\delta E_{it} = E_{it} - \lambda E_{i,t-1}$$

Using these definitions, the alternative decomposition equation can be derived from the material balance equations analogous to the decomposition equation (95). After some algebraic manipulations, the decomposition (in matrix notations) is given *by*

$$\delta X_t = R_{t-1} D_{t-1} \delta F_t \qquad (a)$$

$$+ R_{t-1} \delta E_t \qquad (b)$$

$$+ R_{t-1} \Delta D_t \lambda (F_{t-1} + V_{t-1}) \qquad (c)$$

$$+ R_{t-1} D_{t-1} \Delta A \lambda X_{t-1} \qquad (d). \quad (99)$$

---

[2] Chenery, H. B., S. Shishido, and T. Watanabe (1962)

The deviation from proportional growth in output in sector *i* is seen to be the sum of four sets of structural changes:

(a) Effects of deviations in domestic demand in all sectors(DD),

(b) Effects of deviations in exports in all sectors(EE),

(c) Effects of changes in the import structure of intermediate and final goods(IS),

(d) Effects of changes in the matrix of input-output coefficients(IO).

In equation (99), the material balance equation in the terminal year is compared not with its counterpart in the initial year but with the hypothetical material balance equation in the terminal year under the assumption of balanced growth.

Difference between two Methods: A Graphic Representation

The figure 1 is a graph of growth and structural change in a two-sector model. Initially, the economy is at point I and is producing $X_{1,t-1}$ and $X_{2,t-1}$ (the subscript refers to the sector and the superscript to the period). Later, the economy is at point II and is producing X_{1t} and X_{2t}. Aggregate output has grown from $X_{t-1} = X_{1,t-1} + X_{2,t-1}$ to $X_t = X_{1t} + X_{2t}$, where

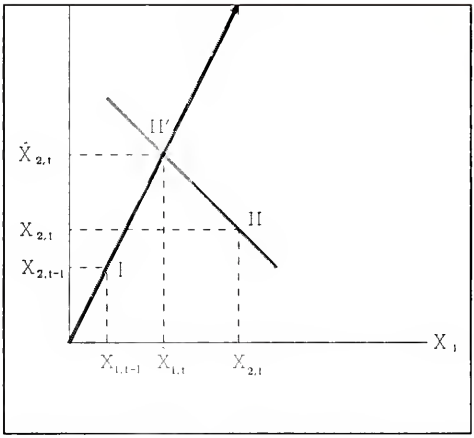

Figure 1 *Measures of Growth and Structural Change*

real output is defined simply as the sum of sectoral outputs in constant prices.

The change in aggregate output is given by the sum of the changes in sectoral output: $\Delta X = \Delta X_1 + \Delta X_2$ (where $\Delta X_i = X_{it} - X_{i,t-1}$). The change in aggregate output, however, conceals significant changes in the structure of production. To measure this structural change, the movement from point I to point II is decomposed into two steps. First, the economy is assumed to grow so that all sectors expand proportionately. This balanced growth takes the economy from point I to point II', with outputs X_{1t} and X_{2t}, and the same aggregate output as at point II. Then, holding aggregate output fixed, the structure of production is changed; the changes in sectoral production generated by moving from point II' to point II are given by δX_1 and δX_2. Therefore, the method based on absolute

growth measures the change Δ in variables and the method based on proportional growth measures the change δ in variables.

In the decompositions of the deviation measure, let's compare equation (95) with equation (99) to examine the difference between the ΔX decomposition and the δX decomposition. The last two terms in equation (95) are nearly identical with the corresponding terms in equation (99). Given that the nonproportional components of domestic demand and export growth are generally smaller than their increments, the relative importance of import substitution and of changes in input-output coefficients will be greater in accounting for δ changes than in accounting for Δ changes.

Input-output Data base

I focused on an input-output accounting framework to measure the degree to which domestic demand, exports, import substitution, and technological change have each contributed to output growth. Since this accounting can be done at either a broad macroeconomic level or for narrowly defined industrial sectors, it provides a rich set of insights into the detailed workings of the Korean economy.

This analysis of the sources of industrial growth and structural change is based on five input-output tables: 1975, 1978, 1980, 1983, and 1985. Although the input-output tables are available for four additional years (1960, 1966, and 1968, 1970) in Korea, I used only five tables to economize on data

and computing costs since I focused on the analysis of policy change of the period in which Korea experienced the economic recession because of the second oil shock and the subsequent recession in the advanced countries.

The Bank of Korea has provided five tables which have about 60 sectors. All the tables are compiled in terms of current producers' prices. The measurement of sources of growth is most meaningfully conducted in terms of constant price. Thus it is necessary to deflate the current price input-output statistics to obtain constant price figures. For this I deflated all the tables with IMF wholesale price indices. While this procedure suffices to insure that, on the average, changes over time are not mis-stated because of price level changes, it fails to account for relative price changes. The changes of relative prices can take place owing to the price level of imported commodities, the price level of exports and the exchange rates on imports and exports.

Except for the two tables for 1980 and 1983, which have 19 sectors, all tables have about 60 sectors. So I had to make all the tables into 19 sectors by aggregating the detailed sectors.

Estimation of Sources of Growth: SAS/IML

I estimated the sources of growth on the demand side by using SAS/IML (Interactive Matrix Languages). The total change in sectoral output is decomposed into its sources by category

of demand. The total change in output equals the sum of the changes in each sector and can also be decomposed either by sector or by category of demand. The relations can be shown schematically as follows:

Notations

DD = effect of deviations in Domestic Demand expansion

EE = effect of deviations in Export Expansion

IS = effect of changes in Import Substitution

IO = effect of the changes in Input-Out coefficients.

$$
\begin{array}{lllll}
DD_1 + & EE_1 + & IS_1 + & IO_1 = & \Delta X_1 \\
DD_2 + & EE_2 + & IS_2 + & IO_2 = & \Delta X_2 \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
DD_n + & EE_n + & IS_n + & IO_n = & \Delta X_n \\
\hline
\Sigma DD_i + & \Sigma EE_i + & \Sigma IS_i + & \Sigma IO_i = & \Sigma \Delta X_i
\end{array}
$$

Reading down columns gives the sectoral composition of each demand category; reading across rows gives the decomposition of changes in sectoral demand by different demand categories. Growth contributions in each period were first calculated at the 19 sector level and then aggregated before converting to percentage.

While the tables of the 19 sector model are presented in Appendix, the summary tables, i.e. sources of aggregated output growth, sources of sectoral output growth, and the sectoral comparison of EE and IS in ΔX and δX are summarized

in Table III-2, III-4, III-6, and III-7.

Interpretation of the Results

While it is apparent from some research results that Korea's industrial development has clearly been export-led, this stands out even more dramatically when the sources of Korea's industrialization are compared with international norms on the demand side. Before I examine the results of my calculation of the sources of growth in the period 1975-1985, I refer to the results from Frank, Kim and Westphal (1975) to compare the Korea's development pattern with the norms on the demand side.

The sources of Korea's industrialization from 1960 to 1968 are compared in Table III-1 with crudely estimated cross-country norms for the growth of per capita income from $100 to

Table III-1. Sources of Industrialization[3]

	DD	EE(%)	IS
Korea (1960-68)	60	38	2
Large Country Norm	55	24	21
All Country Norm	50	18	32

[3] Frank, Ch. R., K. S. Kim, and L. E. Westphal (1975), p95.

$200. While import substitution contributed very little to Korea's industrialization, the growth of exports contributed more than twice the relative amount that is typically associated with the doubling of per capita income from $ 100 to $ 200. The analysis of Frank, Kim and Westphal, however, had an analytic problem in that a fixed coefficient input-output table was assumed. Furthermore these results are unfortunately not comparable to ours because of differences in classification and level of aggregation.

Table III-2 highlights the impact of the shift in Korea's development strategy and the technological change in the early 1980s. According to the ΔX based estimates found in Table III-2, the EE effects on the growth of output dominated over the IS effect except during the period 1978-1980. In the period 1978-1980, the IS effect was a little greater than the EE effect in ΔX. Until 1978, Korea pursued export-oriented economic growth. However, Korea faced some major constraints to the promotion of exports. The advanced countries underwent a prolonged recession after the second oil shock. This led to increased protectionism in the advanced countries. In this period, the greatest effect on the growth of output in Korea was the change in input-output coefficients. This fact reflects that Korea experienced the technological change in the face of the second oil shock and world-wide recession to achieve steady economic growth. Moreover, the resource misallocation which was led by the government's overambitious

Table III-2. Sources of Aggregated Output Growth (in percent)

	Δ X				δ X			
	DD	EE	IS	IO	DD	EE	IS	IO
1975-1978	76.78	28.34	3.06	-8.18	54.69	-3.80	-65.07	110.76
1978-1980	11.88	11.34	12.98	63.79	23.04	15.54	10.73	50.69
1980-1983	71.24	43.54	10.23	-25.01	75.54	-24.55	-27.97	76.98
1983-1985	65.21	33.02	3.79	-2.02	-54.36	-1.44	15.49	-16.59

Note) Δ X: the incremental measured by the method based on absolute growth
δ X: the incremental measured by the method based on proportional grow

promotion of heavy and chemical industries since the mid-seventies accelerated the changes in the input-output coefficients. After these big changes in the input-output coefficient, the difficulties that Korea encountered during the 1979-1981 had been largely overcome by the middle of 1984.

If we examine the estimates based on the δX decomposition, we find that export promotion no longer contributes to the growth of output. In Table III-2, we can observe the contribution of changes in the input-output coefficients to the growth of output in the decompositions of δX.

To examine the structural changes, let examine the Table

III-4 which classifies output into five sectors: primary industry, light industry, heavy industry, social overhead and services, and dummy sector. The aggregation scheme of nineteen industries into five sectors is shown in Table III-3.

According to Table III-4, domestic demand expansion was a dominant factor in primary industry's output over the entire period (1975-1985). The export expansion contributed to output growth positively, but Table III-4 showed the great reduction of the EE effect in the decomposition of δX. In the decomposition of δX, the contributions of the changes of technology in manufacturing to the growth of output have different patterns between light indusry and heavy industry in the entire period (1978-1985). The contributions of the changes in the input-output coefficients of light industry did not vary sharply from period to period. In contrast, the contributions of the changes of heavy industry changed radically from period to period. In the period 1978-1980, for example, the contributions of the changes in the input-output coefficients of heavy industry was the greatest one among factors of decompositions. In the period 1980-1983, however, the changes in the coefficients of heavy industry contributed by minus 566.8%. These empirical results indicate that the heavy industry experienced the radical change in the government's development policy. The government's overambitious promotion of heavy and chemical industries took place since the mid-seventies. The IS effects were minor

Table III-3. Sector Classification for Five Sectors

5 Aggregated Sector Classification	19 Aggregated Sector Classification
1. Primary industry	1. Agriculture, forestry and fisheries 2. Mining
2. Light industry	3. Food, beverages and tobacco 4.Textiles and leather 5. Lumber and wood products 6. Paper, printing and publishing 8. Nonmetalic mineral products 11. Miscellaneous manufacturing
3. Heavy industry	7. Chemicals and chemical products 9. Primary metal manufacturing 10. Metal products and machinery
4. Social overhead & services	12. Construction 13. Electric, gas and water services 14. Wholesale and retail trade 15. Transportation, warehousing and communications 16. Finance, insurance and real estate 17. Public administration and defence 18. Restaurants, hotels and other services
5. Dummy sector	19. Dummy sector

Table III-4. Sources of Sectoral Output Growth: 5 Sector Model (in percent)

	Δ X				δ X			
	DD	EE	IS	IO	DD	EE	IS	IO
1975-1978								
1. Primary Industry	69.8	10.6	23.3	-3.7	-303.1	-79.4	317.4	-34.9
2. Light Industry	71.7	40.3	-1.2	-10.9	33.0	39.4	2.7	25.0
3. Heavy Industry	71.9	52.4	-.7	-23.7	390.6	640.6	-20.2	-911.0
4. Social Overhead & Services	84.2	15.7	-.3	.4	48.9	23.2	-2.2	30.1
5. Dummy sector	85.9	37.5	-6.1	-17.4	39.6	18.2	16.5	25.7
1978-1980								
1. Primary Industry	177.3	7.8	42.5	-127.7	125.9	-3.6	34.4	-63.9
2. Light Industry	50.5	1.0	10.4	38.2	56.2	4.5	7.2	32.0
3. Heavy Industry	-12.8	19.0	32.1	61.8	-7.5	25.1	31.1	51.3
4. Social Overhead & Services	43.2	12.1	.8	43.9	51.4	13.4	.9	34.3
5. Dummy sector	6.7	-11.8	33.3	71.7	23.8	-5.2	31.5	49.9
1980-1983								
1. Primary Industry	100.5	10.5	28.2	-39.1	33.5	39.2	-76.2	103.5
2. Light Industry	101.9	84.1	-3.3	-82.7	56.1	14.6	3.5	25.8
3. Heavy Industry	41.3	65.7	17.7	-24.8	-305.8	612.1	360.5	-566.8
4. Social Overhead & Services	84.0	23.8	2.9	-10.7	81.2	-53.7	-23.1	95.6
5. Dummy sector	85.7	67.9	18.9	-72.5	53.0	-44.7	-29.1	120.8
1983-1985								
1. Primary Industry	69.9	14.7	18.8	-3.4	143.1	26.8	-49.8	11.2
2. Light Industry	43.3	40.3	4.7	14.8	-211.8	7.6	31.8	74.7
3. Heavy Industry	50.4	63.8	5.6	-19.8	-16.4	15.1	8.1	-33.6
4. Social Overhead & Services	87.3	13.2	.1	-.6	3.6	-30.4	2.3	-13.9
5. Dummy sector	73.6	14.9	-4.2	15.7	-8.7	-56.3	-10.2	28.0

except the recession period. The IO effects of all industries except primary industry are high just in the recession period.

It is interesting to compare these findings of proportional method on Korean economy to the results which are obtained in the analysis of the patterns of Japanese Growth, 1935-1954 by H. B. Chenery, S. Shishido, and T. Watanabe (1962).

The relative contribution of export expansion is not emphasized by the proportional method in the case of Korean economy. The similar phenomenon can be found from Table III-5.

For direct comparisons, the analysis of Chenery et al. has some limitations since they assumed that the coefficient matrix of the input-output table was fixed, that is, there was no technological change. However, their results imply the following fact. Many people assumed that the Japanese pattern would be export-led, but the fact is that it was led by import substitution. It is also believed that the pattern of Korean development is export-led. But the results based on the proportional method do not support this conclusion.

Most of the major manufacturing subsectors displays a pattern consistent with that for manufacturing as a whole except several subsectors. If we focus on the comparisons of trade policy of each sector, we can compare the relative importance of export expansion and import substitution in Tables III-6 and III-7.

Table III-5. Relative Importance of Changes in Final Demand and Trade, 1935-1954[4] (Billions of 1951 yen)

	Final Demand	Exports	Imports	Total
I A. Agriculture	50	-268	397	179
I B. Mining	-43	-48	62	-29
II A. Food	123	-86	8	45
II B. Textiles	-16	-807	93	-730
II C. Other Finished Goods	-113	-81	44	-150
II D. Intermediate Products	-271	-280	535	-15
III. Services	378	-451	152	79

Table III-6 shows that the relative importance of EE and IS in some subsectors changed dramatically in the recession period. Specifically the heavy and chemical industries experienced the reverse of relative importance between EE and IS. If we compare the relative importance of EE and IS between ΔX and δX, the EE is of less importance in δX than in ΔX.

During the past ten years much research results about export expansion and economic growth has confirmed the positive relationship. However, while the high positive correlation between export performance and economic growth is

[4] H.B.Chenery, S.Shishido, and T.Watanabe (1962), pp 112.

Table III-6. Sectoral Comparison of EE and IS in ΔX
(Method based on absolute growth)
(in percent)

	75-78		78-80		80-83		83-85	
	EE	IS	EE	IS	EE	IS	EE	IS
1.	9.9	< 14.0	9.6	< 18.3	6.4	< 27.8	9.6	< 17.0
2.	14.8	< 77.4	-19.2	<423.5	177.6	> 41.5	65.9	> 37.3
3.	4.1	> -1.8	-0.6	< 8.3	13.4	< 32.6	11.1	> 10.5
4.	59.1	> .3	610.6	>363.4	229.7	>-87.0	63.0	> 4.9
5.	42.6	> -1.4	131.1	> 12.4	-316.8	<-32.4	22.4	>-32.5
6.	30.2	> 3.0	8.1	> 7.0	-304.5	<551.6	25.7	> -5.5
7.	57.4	> -.4	12.8	< 20.3	118.9	>-15.7	73.8	> -7.1
8.	35.3	> -7.5	9.0	< 11.9	57.8	>-30.9	8.1	> .0
9.	104.7	>-20.7	33.9	< 41.0	90.2	> 45.7	458.8	> 66.8
10.	41.8	> 2.3	7.5	<142.8	48.9	> 19.5	47.2	> 11.7
11.	75.3	> -4.5	-390.1	<126.1	68.3	> -2.8	116.9	> 1.9
12.	.7	> 0	1.2	> 1.0	4.5	> .3	4.1	> .1
13.	34.5	> 4.8	7.2	< 7.9	28.4	> 4.4	66.5	> 4.6
14.	30.4	> .3	164.8	> 93.3	91.6	> -.4	22.0	> 5.8
15.	41.8	> -3.8	50.6	>-13.8	42.3	> 9.7	26.7	> -6.3
16.	12.0	> 1.5	4.2	< 8.2	31.1	> 7.5	7.8	> -1.0
17.	0	0	.5	> -3.0	1.4	> 1.1	-.3	< 8.5
18.	6.0	> -.6	2.9	> -3.4	11.1	> -.8	25.0	> -5.4
19.	37.5	> -6.1	-11.8	< 33.3	67.9	> 18.9	14.9	> -4.2

Table III-7. Sectoral Comparison of EE and IS in δX
(Method based on proportional growth)
(in percent)

	75-78		78-80		80-83		83-85	
	EE	IS	EE	IS	EE	IS	EE	IS
1.	-11.7<	90.8	5.2<	21.9	55.6>-116.0		45.1>-89.8	
2.	1.1<	113.7	137.5>-1296.5		6.5>	-10.6	42.5<	81.3
3.	113.8>	14.6	-.2<	5.1	5.6>	-13.3	-3.7>-76.1	
4.	97.6>	-24.4	131.6>	42.1	14.1<	30.6	19.7>	5.7
5.	31.1>	-2.7	194.6>	17.0	129.7>	7.9	13.4>	9.5
6.	-125.9>-279.7		10.2>	6.5	5.8>	-33.0	23.1>-24.4	
7.	-134.0<	1.2	16.7<	17.2	-13.1<	13.3	59.9>-14.8	
8.	59.3>	-25.6	11.5>	10.8	12.2<	13.7	-67.6<	.6
9.	180.7>	-45.5	40.7<	43.4	-87.5>-187.0		-142.9<	83.3
10.	45.7>	2.9	29.0<	151.7	60.8>	34.4	16.3>	10.6
11.	80.0>	-5.2	-170.7<	51.1	146.0>	-36.7	66.1>	2.7
12.	.1>	.0	1.4>	.9	56.9>	5.2	15.4>	2.4
13.	71.9>	34.1	9.3>	7.8	23.7>	13.8	-47.5<-21.5	
14.	79.2>	3.5	50.9>	18.2	-15.0<	2.3	-3.7<	9.9
15.	70.0>	-12.1	50.9>	-10.6	55.8>	55.5	-129.2<-18.1	
16.	10.0>	2.8	5.9<	7.3	-2.2>	-8.6	3.4>	-.5
17.	.0	.0	.5>	-1.4	12.0<	13.2	1.0>	-6.5
18.	4.4>	-1.1	4.1>	-2.7	24.5>	-4.5	-7.6<	5.0
19.	68.4>	-50.8	-7.0<	33.4	-53.2<	-32.4	-25.3<	-6.5

an accepted fact in development economics, recent studies fail to confirm that the former causes the latter.

This analysis indicates that domestic demand and export expansion were two major factors contributing to growth and structural change. However, import substitution and technological change were more important than export expansion in the recession period (1979-1981) in explaining growth.

In addition, if we take the method of measurement based on proportional growth, export expansion no longer plays the consistent role that is attributed to it by the method based on absolute growth.

CHAPTER 4
SUMMARY AND CONCLUSION

I have analyzed the productivity change and pattern of production for industrial sectors in Korean manufacturing by estimating translog production functions and value shares and testing restrictions which are imposed by producer's theory in the supply-side analysis. In the demand-side analysis, I have measured the effect of changes in demand on the growth of outputs of industrial sectors and derived some implications about trade policies: export promotion policy and import substitution policy.

In the supply-side analysis, we obtain the best results from the model restricted to constant returns to scale by the estimation method of seemingly unrelated regression based on statistical significance of estimates and production theory.

The parameter estimates of translog production function provide implications about share elasticities and biases of productivity. We classify the industries according to the biases of productivity growth. The remarkable characteristic in our classification is capital-saving. This fact raises doubt about the role of capital accumulation which traditional growth theory emphasizes in the development process of

developing countries.

If we compare the TFP measured by translog production function to the TFP which others have measured by growth accounting, we obtain different results according to the industry. For some industries TFP's measured by translog production function are greater than TFP's measured by growth accounting, and for other industries less. This phenomenon is due to the fact that TFP measured by growth accounting cannot explain the effect of bias of productivity growth on TFP, while TFP measured by translog production function reflects the effect of bias of productivity growth.

In the demand-side analysis, domestic demand and export expansion were two major factors contributing to growth and structural change. However, import substitution and technological change were more important than export expansion in the recession period. Besides, if we measure the relative contribution of export expansion by the method based on proportional growth, we do not observe the role of export expansion which is attributed by the method based on absolute growth.

If we relate productivity changes of industrial sectors in manufacturing during 1975-83 to the measurement of sources of growth for the same industrial sectors in manufacturing during the same period, we do not find any correlation between the increase of TFP and trade policies. Our observations on total factor productivity implies that the technical progress takes

a relatively small role in the industrialization process since the rate of productivity growth is decelerating.

APPENDIX

Table II-8. Diagonal Matrix of Cholesky Factorization

I.FIML

1) Generalized Model

1.Food, beverages & tobacco

0.06028
4.63966
-0.10437

2.Textiles & leather

0.04309
2.38705
-0.04185

3.Lumber & wood products

0.11556
3.81398
-0.01627

4.Paper, printing & publishing

-0.10252
0.82301
0.13600

5.Chemicals & chemical products

-0.07557
36.88665
0.02415

6.Nonmetalic mineral products

-0.18428
-2.79678
-0.04545

7.Primary metal manufacturing

-0.12738
-1.14135
-0.01693

8.Metal products & machinery

-0.22741
1.14399
-0.04406

9.Miscellaneous manufacturing

-0.07471
3.86755
-0.03126

10.The whole manufacturing

0.05539
22.15497
-0.01212

2) The Model under Constant Return to Scale

1.Food, beverages & tobacco

-0.16665
-0.00051
-0.00000

2.Textiles & leather

0.02607
-0.03638
0.00000

3.Lumber & wood products

0.10554
0.01813
0.00000

4.Paper, printing & publishing

-0.08747
0.00288
-0.00000

5.Chemicals & chemical products

-0.04982
0.02171
0.00000

6.Nonmetalic mineral products

-0.10075
-0.04577
0.00000

7.Primary metal manufacturing

-0.18127
-0.01470
-0.00000

8.Metal products & machinery

-0.15002
-0.03652
-0.00000

9.Miscellaneous manufacturing

-0.17455
-0.01737
-0.00000

10.The whole manufacturing

0.05166
-0.01500
-0.00000

II.SUR

1) Generalized model

1.Food, beverages & tobacco

0.08910
4.10452
-0.07681

2.Textiles & leather

-0.02319
2.03831
-0.00648

3.Lumber & wood products

0.11146
3.94681
-0.02522

4.Paper, printing & publishing

-0.06844
3.40890
0.04821

5.Chemicals & chemical products

-0.11675
8.76096
0.02159

6.Nonmetalic mineral products

0.00725
1.81824
-0.05631

7.Primary metal manufacturing

0.13119
-0.01649
-0.01653

8.Metal products & machinery

-0.22888
3.76045
-0.04245

9.Miscellaneous manufacturing

0.02431
0.08809
-0.04082

10.The whole manufacturing

0.06293
18.14782
-0.00990

2) The Model under Hicks Neutrality

1.Food, beverage & tobacco

-0.05375
0.96644
-0.00939

2.Textiles & leather

-0.04362
-0.02710
-0.00517

3.Lumber & wood products

0.11753
0.01442
-0.03530

4.Paper, printing & publishing

0.01825
0.38384
-0.01479

5.Chemicals & chemical products

-0.06181
1.16399
0.01749

6.Nonmetalic mineral products

0.04505
0.50963
-0.06598

7.Primary metal manufacturing

0.15134
0.72318
-0.02119

8.Metal products & machinery

-0.23177
-0.42738
-0.03218

9.Miscellaneous manufacturing

0.05039
0.21689
-0.02169

10.The whole manufacturing

0.05836
0.36004
-0.01155

3) The Model under Constant Return to Scale

1.Food, beverage & tobacco

-0.06170
0.03119
-0.00000

2.Textiles & leather

-0.00343
-0.00051
-0.00000

3.Lumber & wood products

0.10603
0.01883
-0.00000

4.Paper, printing & publishing

-0.00697
-0.00156
-0.00000

5.Chemicals & chemical products

-0.07193
0.02454
-0.00000

6.Nonmetalic mineral products

-0.01860
-0.04337
-0.00000

7.Primary metal manufacturing

0.06685
-0.02712
0.00000

8.Metal products & machinery

-0.14904
-0.03575
-0.00000

9.Miscellaneous manufacturing

0.00064
-0.14484
0.00000

10.The whole manufacturing

0.06623
-0.00954
0.00000

4) The Model under Existence of Value-added function

1.Food, beverage & tobacco

-0.01198
4.25468
-0.03367

2.Textiles & leather

0.02774
1.52091
-0.00838

3.Lumber & wood products

0.04432
4.22041
-0.00850

4.Paper, printing & publishing

0.02282
3.51295
0.06909

5.Chemicals & chemical products

0.01520
-8.99473
0.01948

6.Nonmetalic mineral products

0.03370
2.04482
-0.05155

7.Primary metal manufacturing

0.01434
1.16434
-0.01796

8.Metal products & machinery

0.01304
2.17598
-0.04084

9.Miscellaneous manufacturing

0.01516
0.16856
-0.03078

10.The whole manufacturing

0.01757
10.80001
-0.03258

Table II-9. Total Factor Productivity by FIML

Year	Industry		
	1. Food, beverages & tobacco	2. Textiles & leather	3. Lumber & wood products
1963	0.13287	-0.02661	0.09446
1964	0.11786	-0.03156	0.07365
1965	0.10402	-0.03667	0.05380
1966	0.09443	-0.04253	0.03457
1967	0.08771	-0.05317	0.01083
1968	0.08114	-0.05652	-0.01363
1969	0.07102	-0.05149	-0.02972
1970	0.06401	-0.04034	-0.02924
1971	0.05471	-0.03096	-0.01824
1972	0.04334	-0.03127	-0.01134
1973	0.03186	-0.03966	-0.01050
1974	0.02558	-0.05018	-0.00972
1975	0.02628	-0.06157	-0.00917
1976	0.02648	-0.06885	-0.01484
1977	0.02404	-0.06707	-0.02847
1978	0.01968	-0.05067	-0.03734
1979	0.02157	-0.02299	-0.03123
1980	0.03013	0.00563	-0.01125
1981	0.04174	0.03067	0.01517
1982	0.04844	0.05118	0.03285
1983	0.04940	0.06419	0.04048
mean	0.05697	-0.02907	0.00481

Year	Industry		
	4.Paper, printing & publishing	5.Chemicals & chemical products	6.Nonmetalic mineral products
1963	0.04206	0.57985	-0.04764
1964	0.03788	0.58364	-0.03479
1965	0.03389	0.57856	-0.02270
1966	0.02917	0.59733	-0.00141
1967	0.02655	0.59024	0.02275
1968	0.02426	0.51129	0.04053
1969	0.02310	0.42549	0.04461
1970	0.02257	0.40190	0.03747
1971	0.02201	0.42508	0.02444
1972	0.02308	0.38831	0.01594
1973	0.02361	0.29622	0.01764
1974	0.02298	0.16844	0.02471
1975	0.02173	0.04931	0.02920
1976	0.02144	-0.05434	0.03357
1977	0.02191	-0.10424	0.04547
1978	0.02245	-0.09283	0.06173
1979	0.02288	-0.02917	0.06730
1980	0.02485	0.05203	0.05907
1981	0.02687	0.16301	0.04233
1982	0.02906	0.12258	0.03131
1983	0.02971	0.39529	0.02850
mean	0.02631	0.28800	0.02476

Year	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
1963	-0.06482	-0.11721	0.43187
1964	-0.05867	-0.10649	0.31717
1965	-0.05320	-0.09579	0.21876
1966	-0.04513	-0.08807	0.14428
1967	-0.03677	-0.08018	0.10581
1968	-0.02760	-0.07357	0.05619
1969	-0.02391	-0.06532	-0.00195
1970	-0.02029	-0.05306	-0.02582
1971	-0.01588	-0.04148	-0.02553
1972	-0.00128	-0.03490	-0.01277
1973	0.01223	-0.03498	0.01511
1974	0.02023	-0.03432	0.06294
1975	0.02702	-0.03320	0.09813
1976	0.03451	-0.03243	0.09504
1977	0.04640	-0.03212	0.09568
1978	0.05574	-0.02863	0.13435
1979	0.06194	-0.01679	0.20722
1980	0.06565	0.00132	0.27897
1981	0.06659	0.02226	0.33497
1982	0.06544	0.03964	0.37442
1983	0.06224	0.05282	0.40861
mean	0.00812	-0.04060	0.15778

Year	Industry The whole manufacturing
1963	0.08492
1964	0.13445
1965	0.12134
1966	0.12523
1967	0.10519
1968	0.10798
1969	0.12306
1970	0.17909
1971	0.27182
1972	0.29487
1973	0.22334
1974	0.10988
1975	0.02799
1976	-0.06102
1977	-0.11849
1978	-0.16032
1979	-0.19949
1980	-0.21949
1981	-0.20048
1982	-0.12060
1983	0.30399
mean	0.05396

Table II-10. Total Factor Productivity under Constant Return to Scale by FIML

Year	Industry		
	1. Food, beverages & tobacco	2. Textiles & leather	3. Lumber & wood products
1963	0.02884	-0.07969	0.03795
1964	0.03006	-0.06977	0.03525
1965	0.03098	-0.06026	0.03303
1966	0.03188	-0.05241	0.03083
1967	0.03294	-0.04112	0.02879
1968	0.03406	-0.03140	0.02665
1969	0.03509	-0.02163	0.02435
1970	0.03605	-0.01160	0.02159
1971	0.03729	-0.00165	0.01918
1972	0.03855	0.00866	0.01637
1973	0.03966	0.01862	0.01426
1974	0.04070	0.02863	0.01199
1975	0.04182	0.03845	0.00990
1976	0.04313	0.04818	0.00748
1977	0.04446	0.05795	0.00512
1978	0.04564	0.06768	0.00299
1979	0.04649	0.07760	0.00097
1980	0.04718	0.08750	-0.00107
1981	0.04802	0.09733	-0.00337
1982	0.04912	0.10705	-0.00582
1983	0.04993	0.11522	-0.00809
mean	0.03961	0.01825	0.01468

Year	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
1963	0.00235	0.06469	0.03464
1964	0.00328	0.05897	0.03417
1965	0.00421	0.05391	0.03335
1966	0.00507	0.04850	0.03173
1967	0.00600	0.04289	0.02926
1968	0.00698	0.03740	0.02795
1969	0.00820	0.03126	0.02719
1970	0.00953	0.02516	0.02738
1971	0.01082	0.01918	0.02691
1972	0.01221	0.01370	0.02709
1973	0.01339	0.00713	0.02659
1974	0.01451	0.00532	0.02535
1975	0.01560	-0.00160	0.02390
1976	0.01693	-0.00787	0.02313
1977	0.01831	-0.01396	0.02222
1978	0.01966	-0.02042	0.02073
1979	0.02086	-0.02718	0.01863
1980	0.02215	-0.03430	0.01664
1981	0.02344	-0.04126	0.01489
1982	0.02484	-0.04811	0.01394
1983	0.02612	-0.05402	0.01316
mean	0.01355	0.00759	0.02471

Year	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
1963	0.03317	0.02287	0.03419
1964	0.02930	0.02334	0.03161
1965	0.02538	0.02456	0.02913
1966	0.02248	0.02437	0.02667
1967	0.02140	0.02406	0.02631
1968	0.02330	0.02362	0.02649
1969	0.02205	0.02259	0.02781
1970	0.02130	0.02116	0.02652
1971	0.02034	0.01987	0.02505
1972	0.02688	0.02151	0.02411
1973	0.02942	0.02354	0.02341
1974	0.02615	0.02393	0.02258
1975	0.02409	0.02475	0.02239
1976	0.02341	0.02532	0.02260
1977	0.02507	0.02737	0.02307
1978	0.02353	0.02752	0.02253
1979	0.02036	0.02638	0.02174
1980	0.01729	0.02540	0.02191
1981	0.01371	0.02495	0.02112
1982	0.01222	0.02595	0.02045
1983	0.01134	0.02679	0.01909
mean	0.02249	0.02428	0.02470

Year	Industry The whole manucturing
1963	0.04405
1964	0.04140
1965	0.03876
1966	0.03616
1967	0.03350
1968	0.03085
1969	0.02822
1970	0.02557
1971	0.02293
1972	0.02026
1973	0.01762
1974	0.01493
1975	0.01230
1976	0.00966
1977	0.00701
1978	0.00438
1979	0.00175
1980	-0.00087
1981	-0.00349
1982	-0.00613
1983	-0.00879
mean	0.01762

Table II-11. Total Factor Productivity by SUR

Year	Industry		
	1. Food, beverages & tobacco	2. Textiles & leather	3. Lumber & wood products
1963	0.12196	-0.00998	0.10000
1964	0.10884	-0.01273	0.07873
1965	0.09678	-0.01598	0.05833
1966	0.08835	-0.02125	0.03848
1967	0.08229	-0.02705	0.01396
1968	0.07634	-0.02903	-0.01130
1969	0.06740	-0.02492	-0.02804
1970	0.06123	-0.01608	-0.02784
1971	0.05297	-0.00856	-0.01707
1972	0.04293	-0.00773	-0.01034
1973	0.03282	-0.01307	-0.00991
1974	0.02721	-0.01987	-0.00948
1975	0.02760	-0.02745	-0.00936
1976	0.02747	-0.03212	-0.01535
1977	0.02506	-0.03021	-0.02945
1978	0.02107	-0.01779	-0.03886
1979	0.02259	0.00295	-0.03319
1980	0.02991	0.02439	-0.01347
1981	0.03977	0.04318	0.01292
1982	0.04532	0.05863	0.03048
1983	0.04599	0.06921	0.03781
mean	0.05447	-0.00550	0.00557

Year	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
1963	0.07922	0.55934	0.11636
1964	0.06284	0.54421	0.10606
1965	0.04746	0.52478	0.09569
1966	0.03368	0.51112	0.07886
1967	0.02395	0.49342	0.05881
1968	0.01810	0.46196	0.04436
1969	0.01146	0.43181	0.03851
1970	0.00453	0.41307	0.04064
1971	-0.00119	0.40258	0.04488
1972	0.00120	0.37903	0.04788
1973	0.00787	0.34934	0.04408
1974	0.00883	0.29458	0.03601
1975	0.00653	0.26120	0.02891
1976	0.00203	0.22816	0.02311
1977	0.00055	0.20440	0.01298
1978	0.00075	0.19346	-0.00058
1979	0.00581	0.19335	-0.00948
1980	0.01839	0.19794	-0.01068
1981	0.03129	0.20741	-0.00678
1982	0.04122	0.18841	-0.00448
1983	0.04503	0.22394	-0.00633
mean	0.02141	0.34588	0.03709

Year	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
1963	0.19822	-0.12461	0.02759
1964	0.18706	-0.10794	0.02755
1965	0.17557	-0.09149	0.02768
1966	0.16532	-0.08201	0.02724
1967	0.15436	-0.07218	0.02654
1968	0.14266	-0.06565	0.02604
1969	0.12899	-0.05459	0.02586
1970	0.11514	-0.03303	0.02371
1971	0.10183	-0.01355	0.02078
1972	0.09213	-0.00888	0.01783
1973	0.08373	-0.02198	0.01462
1974	0.07431	-0.03244	0.01087
1975	0.06341	-0.04182	0.00759
1976	0.05236	-0.05182	0.00548
1977	0.04313	-0.06361	0.00345
1978	0.03366	-0.06614	0.00017
1979	0.02283	-0.04630	-0.00416
1980	0.01020	-0.01010	-0.00828
1981	-0.00417	0.03340	-0.01244
1982	-0.02103	0.06705	-0.01615
1983	-0.03964	0.08961	-0.01964
mean	0.08476	-0.03800	0.01106

Year	Industry The whole manucturing
1963	0.08315
1964	0.12364
1965	0.11277
1966	0.11592
1967	0.09931
1968	0.10148
1969	0.11374
1970	0.15958
1971	0.23553
1972	0.25426
1973	0.19547
1974	0.10217
1975	0.03490
1976	-0.03823
1977	-0.08551
1978	-0.11993
1979	-0.15214
1980	-0.16860
1981	-0.15308
1982	-0.08766
1983	0.26050
mean	0.05654

Table II-12. Total Factor Productivity under Hicks Neutrality by SUR

Year	Industry		
	1. Food, beverages & tobacco	2. Textiles & leather	3. Lumber & wood products
1963	0.07871	-0.05927	0.00296
1964	0.07556	-0.05465	0.00299
1965	0.07241	-0.05003	0.00302
1966	0.06925	-0.04541	0.00305
1967	0.06610	-0.04079	0.00308
1968	0.06295	-0.03618	0.00311
1969	0.05980	-0.03156	0.00314
1970	0.05665	-0.02694	0.00317
1971	0.05350	-0.02232	0.00320
1972	0.05035	-0.01770	0.00323
1973	0.04720	-0.01309	0.00326
1974	0.04404	-0.00847	0.00329
1975	0.04089	-0.00385	0.00332
1976	0.03774	0.00077	0.00335
1977	0.03459	0.00538	0.00338
1978	0.03144	0.01000	0.00341
1979	0.02829	0.01462	0.00343
1980	0.02514	0.01924	0.00346
1981	0.02199	0.02386	0.00349
1982	0.01883	0.02847	0.00352
1983	0.01568	0.03309	0.00355
mean	0.04720	-0.01309	0.00326

Year	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
1963	0.02440	0.51688	0.08417
1964	0.02332	0.49496	0.07900
1965	0.02224	0.47305	0.07384
1966	0.02116	0.45114	0.06867
1967	0.02008	0.42923	0.06351
1968	0.01900	0.40732	0.05834
1969	0.01792	0.38541	0.05318
1970	0.01684	0.36350	0.04801
1971	0.01576	0.34159	0.04285
1972	0.01468	0.31967	0.03768
1973	0.01360	0.29776	0.03252
1974	0.01252	0.27585	0.02735
1975	0.01144	0.25394	0.02219
1976	0.01036	0.23203	0.01702
1977	0.00928	0.21012	0.01186
1978	0.00820	0.18821	0.00669
1979	0.00712	0.16630	0.00153
1980	0.00604	0.14438	-0.00364
1981	0.00496	0.12247	-0.00880
1982	0.00388	0.10056	-0.01397
1983	0.00280	0.07865	-0.01913
mean	0.01360	0.29776	0.03252

Year	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
1963	0.20229	-0.09582	0.03760
1964	0.19121	-0.08979	0.03513
1965	0.18013	-0.08376	0.03266
1966	0.16906	-0.07773	0.03019
1967	0.15798	-0.07170	0.02772
1968	0.14690	-0.06568	0.02524
1969	0.13583	-0.05965	0.02277
1970	0.12475	-0.05362	0.02030
1971	0.11367	-0.04759	0.01783
1972	0.10260	-0.04156	0.01536
1973	0.09152	-0.03553	0.01289
1974	0.08044	-0.02951	0.01042
1975	0.06937	-0.02348	0.00795
1976	0.05829	-0.01745	0.00548
1977	0.04721	-0.01142	0.00300
1978	0.03613	-0.00539	0.00053
1979	0.02506	0.00064	-0.00194
1980	0.01398	0.00666	-0.00441
1981	0.00290	0.01269	-0.00688
1982	-0.00817	0.01872	-0.00935
1983	-0.01925	0.02475	-0.01182
mean	0.09152	-0.03553	0.01289

Year	Industry The whole manucturing
1963	0.20726
1964	0.19856
1965	0.18986
1966	0.18116
1967	0.17245
1968	0.16375
1969	0.15505
1970	0.14635
1971	0.13765
1972	0.12895
1973	0.12025
1974	0.11154
1975	0.10284
1976	0.09414
1977	0.08544
1978	0.07674
1979	0.06804
1980	0.05934
1981	0.05063
1982	0.04193
1983	0.03323
mean	0.12025

Table II-13. Total Factor Productivity under Existence of Value-added by SUR

Year	Industry		
	1. Food, beverages & tobacco	2. Textiles & leather	3. Lumber & wood products
1963	0.13555	-0.01554	0.10502
1964	0.12184	-0.01765	0.08116
1965	0.10883	-0.02052	0.05867
1966	0.09934	-0.02637	0.03700
1967	0.09234	-0.03069	0.01051
1968	0.08551	-0.03238	-0.01674
1969	0.07566	-0.02819	-0.03473
1970	0.06838	-0.01927	-0.03447
1971	0.05941	-0.01164	-0.02218
1972	0.04874	-0.01020	-0.01479
1973	0.03785	-0.01488	-0.01380
1974	0.03122	-0.02092	-0.01297
1975	0.03046	-0.02780	-0.01226
1976	0.02942	-0.03194	-0.01897
1977	0.02622	-0.02975	-0.03452
1978	0.02130	-0.01754	-0.04441
1979	0.02131	0.00276	-0.03725
1980	0.02671	0.02373	-0.01453
1981	0.03477	0.04214	0.01511
1982	0.03895	0.05729	0.03486
1983	0.03813	0.06847	0.04341
mean	0.05866	-0.00766	0.00353

Year	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
1963	0.07619	0.51294	0.12003
1964	0.05934	0.48729	0.10906
1965	0.04327	0.46362	0.09815
1966	0.02951	0.43355	0.08036
1967	0.02001	0.41095	0.05953
1968	0.01497	0.40851	0.04434
1969	0.00814	0.40852	0.03854
1970	0.00059	0.39089	0.04118
1971	-0.00551	0.35992	0.04662
1972	-0.00357	0.34547	0.05015
1973	0.00380	0.34765	0.04634
1974	0.00505	0.35581	0.03813
1975	0.00314	0.36597	0.03122
1976	-0.00234	0.37120	0.02534
1977	-0.00458	0.36107	0.01455
1978	-0.00491	0.33396	0.00022
1979	0.00060	0.29235	-0.00828
1980	0.01394	0.24612	-0.00800
1981	0.02783	0.19131	-0.00203
1982	0.03809	0.17911	0.00150
1983	0.04192	0.07767	0.00012
mean	0.01740	0.34971	0.03938

Year	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
1963	0.16403	-0.12805	0.03486
1964	0.15329	-0.11491	0.03302
1965	0.14298	-0.10213	0.03142
1966	0.13186	-0.09346	0.02973
1967	0.12166	-0.08448	0.02782
1968	0.11297	-0.07753	0.02580
1969	0.10549	-0.06761	0.02366
1970	0.09844	-0.05098	0.02124
1971	0.09077	-0.03562	0.01865
1972	0.08244	-0.03003	0.01607
1973	0.07237	-0.03559	0.01344
1974	0.06166	-0.03911	0.01072
1975	0.05228	-0.04207	0.00803
1976	0.04339	-0.04543	0.00554
1977	0.03352	-0.05027	0.00308
1978	0.02304	-0.04891	0.00049
1979	0.01324	-0.03327	-0.00232
1980	0.00477	-0.00746	-0.00521
1981	-0.00260	0.02274	-0.00809
1982	-0.00766	0.04643	-0.01090
1983	-0.01130	0.06328	-0.01350
mean	0.07079	-0.04545	0.01255

Year	Industry The whole manucturing
1963	0.17851
1964	0.19513
1965	0.18206
1966	0.17690
1967	0.16067
1968	0.15515
1969	0.15542
1970	0.17512
1971	0.21218
1972	0.21636
1973	0.17565
1974	0.11532
1975	0.06965
1976	0.02066
1977	-0.01336
1978	-0.04005
1979	-0.06551
1980	-0.08190
1981	-0.07981
1982	-0.04886
1983	0.14537
mean	0.09546

Table II-14. Parameter Estimates by FIML

Parameter	Industry		
	1. Food, beverages & tobacco	2. Textiles & leather	3. Lumber & wood products
A^i_O	0.2485	1.6524	0.6842
	(0.2682)	(1.5122)	(1.7639)
A^i_K	3.2256	3.0726	2.9122
	(1.3762)	(2.6513)	(2.8322)
A^i_L	-0.0536	0.0773	0.1122
	(-0.3202)	(1.5312)	(2.7626)
A^i_M	0.6028	0.7757	0.7275
	(2.8837)	(5.1442)	(12.6909)
A^i_T	-0.0737	-0.2844	-0.1144
	(-0.5004)	(-2.1005)	(-1.7590)
B^i_{MM}	0.0602	0.0430	0.1155
	(0.5379)	(0.3424)	(2.3244)
B^i_{MK}	0.0414	0.0986	-0.1778
	(0.5058)	(0.4133)	(-2.4793)
B^i_{ML}	-0.0656	-0.0382	-0.0107
	(-0.7461)	(-9.1954)	(-0.6079)
B^i_{MT}	-0.0061	-0.0068	0.0012
	(-0.3279)	(-0.5265)	(0.3156)
B^i_{KK}	4.6681	2.6129	4.0875
	(1.6658)	(2.3126)	(2.4816)
B^i_{KL}	-0.0058	-0.0041	-0.0215
	(-0.1304)	(-0.1082)	(-0.5085)
B^i_{KT}	-0.2321	-0.2022	-0.2136
	(-1.2211)	(-2.2083)	(-2.2500)
B^i_{LL}	-0.0324	-0.0050	-0.0148
	(-0.5922)	(-0.3285)	(-0.5203)
B^i_{LT}	0.0119	0.0062	0.0031
	(0.7870)	(1.3489)	(0.8663)
B^i_{TT}	0.0096	0.0222	0.0094
	(0.7885)	(2.5008)	(1.8668)

Parameter	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
A^i_O	-0.1930	16.4037	-0.8906
	(-0.3719)	(1.1352)	(-1.3974)
A^i_K	0.5092	34.9685	-1.4130
	(0.2451)	(1.2987)	(-0.8715)
A^i_L	0.3211	0.0640	0.2456
	(1.0468)	(1.0897)	(6.7684)
A^i_M	0.4148	1.0258	0.3317
	(1.9336)	(3.2202)	(3.8608)
A^i_T	0.0119	-3.3196	0.1379
	(0.1342)	(-1.1835)	(1.1426)
B^i_{MM}	-0.1025	-0.0755	-0.1842
	(-2.9119)	(-2.6405)	(-2.9339)
B^i_{MK}	-0.0595	0.4174	0.0057
	(-1.4576)	(1.3622)	(0.0547)
B^i_{ML}	-0.0219	0.0035	0.0723
	(-0.1498)	(0.4146)	(3.1761)
B^i_{MT}	0.0237	-0.0252	0.0228
	(1.1960)	(-0.8869)	(2.9056)
B^i_{KK}	0.7884	34.5812	-2.7969
	(0.3111)	(1.3800)	(-1.0798)
B^i_{KL}	0.0063	-0.0682	0.0449
	(0.0690)	(-1.1163)	(1.3354)
B^i_{KT}	-0.0440	-3.4117	0.1586
	(-0.2314)	(-1.3111)	(0.9034)
B^i_{LL}	0.1317	0.0240	-0.0746
	(1.3803)	(4.1751)	(-6.6274)
B^i_{LT}	-0.0125	0.0023	-0.0049
	(-0.4503)	(0.4474)	(-1.4704)
B^i_{TT}	0.0010	0.3287	-0.0109
	(0.1300)	(1.2074)	(-0.8823)

Parameter	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
A^i_O	-0.9109	2.3381	5.0015
	(-0.2449)	(0.0483)	(4.7822)
A^i_K	-0.6090	2.9742	7.0222
	(-0.1256)	(0.0429)	(6.8838)
A^i_L	0.0886	0.0287	0.1682
	(1.0085)	(0.3715)	(3.2579)
A^i_M	0.2929	0.7118	0.5039
	(0.7029)	(4.0644)	(7.7526)
A^i_T	0.1415	-0.3925	-0.9249
	(0.2231)	(-0.0444)	(-7.5348)
B^i_{MM}	-0.1273	-0.2274	-0.0747
	(-6.3180)	(-1.1167)	(-3.6923)
B^i_{MK}	-0.0764	0.3399	0.0059
	(-0.2303)	(0.9522)	(0.1173)
B^i_{ML}	-0.0071	0.0379	0.0287
	(-0.7849)	(0.5428)	(2.1120)
B^i_{MT}	0.0428	0.0061	0.0134
	(1.1168)	(0.3858)	(2.7192)
B^i_{KK}	-1.1872	0.6357	3.8670
	(-0.3832)	(0.0127)	(6.1434)
B^i_{KL}	0.0386	-0.0544	0.0151
	(0.5577)	(-0.3735)	(0.7518)
B^i_{KT}	0.0806	-0.2158	-0.6592
	(0.1970)	(-0.0341)	(-8.7324)
B^i_{LL}	-0.0189	-0.0503	-0.0422
	(-4.4165)	(-2.3942)	(-1.3927)
B^i_{LT}	-0.0005	0.0052	-0.0004
	(-0.0687)	(0.7301)	(-0.1049)
B^i_{TT}	-0.0117	0.0325	0.0854
	(-0.2180)	(0.0404)	(10.9636)

Parameter	Industry The whole manucturing
A^i_0	20.9349
	(0.4962)
A^i_K	30.9216
	(0.5735)
A^i_L	0.1343
	(3.7281)
A^i_M	0.7110
	(3.8188)
A^i_T	-4.0321
	(-0.5186)
B^i_{MM}	0.0553
	(0.6237)
B^i_{MK}	-0.0025
	(-0.0186)
B^i_{ML}	-0.0354
	(-0.8086)
B^i_{MT}	-0.0032
	(-0.1904)
B^i_{KK}	22.1551
	(0.6504)
B^i_{KL}	0.0308
	(1.3993)
B^i_{KT}	-2.9370
	(-0.5919)
B^i_{LL}	0.0105
	(0.2253)
B^i_{LT}	0.0002
	(0.0833)
B^i_{TT}	0.3868
	(0.5397)

Table II-15. Parameter Estimates under constant return to scale estimated by FIML

Parameter	Industry		
	1. Food, beverages & tobacco	2. Textiles & leather	3. Lumber & wood products
A^i_O	0.7193	0.6522	0.3769
	(11.3217)	(2.8888)	(2.7437)
A^i_K	0.3511	0.1531	0.3624
	(3.8756)	(2.5170)	(3.7008)
A^i_L	0.0765	0.1819	0.1031
	(2.9228)	(11.1395)	(1.9242)
A^i_M	0.5722	0.6649	0.5345
	(5.0109)	(11.4582)	(7.5363)
A^i_T	0.0301	-0.0922	0.0430
	(3.5526)	(-3.4504)	(2.7155)
B^i_{MM}	-0.1672	0.0331	0.1058
	(-1.1837)	(0.2673)	(2.7206)
B^i_{MK}	0.0520	-0.0020	-0.1087
	(0.4860)	(-0.0161)	(-2.2078)
B^i_{ML}	0.1152	-0.0311	0.0029
	(2.5598)	(-6.3819)	(0.1548)
B^i_{MT}	0.0069	0.0031	-0.0021
	(0.7138)	(0.3583)	(-0.5530)
B^i_{KK}	-0.0165	-0.0338	0.1230
	(-0.1957)	(-0.2601)	(2.0191)
B^i_{KL}	-0.0355	0.0358	-0.0212
	(-1.3956)	(3.0929)	(-0.7350)
B^i_{KT}	0.0001	-0.0045	0.0024
	(0.0067)	(-0.4910)	(0.5843)
B^i_{LL}	-0.0796	-0.0048	0.0183
	(-2.9378)	(-0.5250)	(0.6006)
B^i_{LT}	-0.0070	0.0012	-0.0004
	(-2.6174)	(2.5202)	(-0.2835)
B^i_{TT}	0.0008	0.0095	-0.0021
	(1.0627)	(5.7401)	(-1.3308)

Parameter	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
A^i_O	0.3191	0.5664	0.2918
	(7.3991)	(3.2122)	(3.8805)
A^i_K	0.1152	0.1612	0.1681
	(2.7638)	(6.3651)	(7.2149)
A^i_L	0.3721	0.0524	0.2697
	(5.9772)	(3.6735)	(32.2569)
A^i_M	0.5127	0.7864	0.5622
	(14.1154)	(24.3563)	(29.9434)
A^i_T	-0.0006	0.0623	0.0275
	(-0.1656)	(1.7583)	(1.9445)
B^i_{MM}	-0.0881	-0.0489	-0.0871
	(-4.8007)	(-1.9725)	(-2.6671)
B^i_{MK}	-0.0370	0.0490	0.0568
	(-1.6787)	(2.4855)	(2.4815)
B^i_{ML}	0.1251	-0.0001	0.0303
	(6.9424)	(-0.0186)	(2.8898)
B^i_{MT}	0.0040	0.0082	0.0103
	(5.1185)	(2.8613)	(5.1731)
B^i_{KK}	-0.0131	-0.0274	-0.0815
	(-0.5585)	(-1.8684)	(-3.7453)
B^i_{KL}	0.0501	-0.0216	0.0246
	(1.7115)	(-2.9907)	(3.3754)
B^i_{KT}	-0.0020	-0.0067	-0.0104
	(-1.8308)	(-2.9291)	(-8.0114)
B^i_{LL}	-0.1752	0.0217	-0.0549
	(-4.2925)	(4.3645)	(-6.0009)
B^i_{LT}	-0.0019	-0.0015	0.0002
	(-1.9780)	(-2.2117)	(0.1484)
B^i_{TT}	0.0010	-0.0067	-0.0019
	(2.2599)	(-1.6187)	(-2.0125)

Parameter	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
A^i_O	-0.1474	0.1429	0.2506
	(-3.9730)	(4.5975)	(16.6259)
A^i_K	-0.3506	0.0598	0.2338
	(-7.7545)	(3.6391)	(11.7468)
A^i_L	0.1524	0.1564	0.1596
	(20.1709)	(10.7336)	(17.8335)
A^i_M	1.1982	0.7838	0.6066
	(25.2890)	(31.1844)	(22.7922)
A^i_T	-0.0315	0.0170	0.0324
	(-6.5684)	(1.2792)	(5.4041)
B^i_{MM}	-0.2779	-0.1500	-0.1695
	(-7.1412)	(-1.8258)	(-1.7616)
B^i_{MK}	0.2861	0.1472	0.1391
	(7.2515)	(3.6391)	(2.0778)
B^i_{ML}	-0.0082	0.0028	0.0303
	(-1.2637)	(0.0932)	(0.8957)
B^i_{MT}	0.0370	0.0190	0.0160
	(7.7446)	(2.6891)	(1.9451)
B^i_{KK}	-0.3127	-0.1810	-0.1296
	(-8.1129)	(-5.1256)	(-2.4288)
B^i_{KL}	0.0266	0.0338	-0.0095
	(5.4013)	(1.6671)	(-0.4973)
B^i_{KT}	-0.0379	-0.0187	-0.0148
	(-7.9503)	(-4.1047)	(-2.4768)
B^i_{LL}	-0.0184	-0.0365	-0.0209
	(-5.1384)	(-2.7871)	(-0.9318)
B^i_{LT}	0.0009	-0.0003	-0.0012
	(1.4329)	(-0.1082)	(-0.4880)
B^i_{TT}	-0.0050	-0.0018	-0.0018
	(-7.3256)	(-1.0915)	(-2.0073)

Parameter	Industry The whole manucturing
A^i_0	0.2217
	(2.3887)
A^i_K	0.2351
	(5.2244)
A^i_L	0.1303
	(7.7499)
A^i_M	0.6346
	(16.3433)
A^i_T	0.0468
	(2.6885)
B^i_{MM}	0.0518
	(1.0209)
B^i_{MK}	-0.0244
	(-0.4999)
B^i_{ML}	-0.0274
	(-2.5726)
B^i_{MT}	-0.0004
	(-0.1408)
B^i_{KK}	-0.0031
	(-0.0584)
B^i_{KL}	0.0275
	(3.8396)
B^i_{KT}	0.0001
	(0.0500)
B^i_{LL}	-0.0002
	(-0.0109)
B^i_{LT}	0.0003
	(0.2126)
B^i_{TT}	-0.0026
	(-2.2333)

Table II-16. Parameter Estimates estimated by SUR

Parameter	Industry		
	1.Food, beverages & tobacco	2.Textiles & leather	3.Lumber & wood products
A^i_O	0.1659	1.1305	0.6585
	(0.6863)	(1.2396)	(3.7298)
A^i_K	2.8418	2.1024	2.9565
	(5.6446)	(1.2585)	(5.9839)
A^i_L	-0.0501	0.1036	0.1038
	(-1.4935)	(5.8056)	(7.6439)
A^i_M	0.6463	0.7217	0.7213
	(6.8647)	(13.5675)	(29.0778)
A^i_T	-0.0613	-0.1962	-0.1102
	(-1.6948)	(-1.2906)	(-3.9824)
B^i_{MM}	0.0891	-0.0232	0.1125
	(1.2301)	(-0.5691)	(5.1258)
B^i_{MK}	0.0314	0.1277	-0.1722
	(1.1415)	(1.9932)	(-4.6287)
B^i_{ML}	-0.0605	-0.0059	-0.0173
	(-2.4128)	(-0.4615)	(-1.7064)
B^i_{MT}	-0.0101	-0.0021	0.0018
	(-1.1784)	(-0.4634)	(0.9470)
B^i_{KK}	4.1156	1.3355	4.2129
	(5.9791)	(0.7633)	(5.8213)
B^i_{KL}	-0.0071	-0.0414	-0.0122
	(-0.7366)	(-1.8134)	(-0.6816)
B^i_{KT}	-0.1992	-0.1496	-0.2170
	(-4.8166)	(-0.9835)	(-5.3322)
B^i_{LL}	-0.0357	-0.0053	-0.0221
	(-2.6416)	(-0.5748)	(-1.7485)
B^i_{LT}	0.0116	0.0040	0.0039
	(3.7853)	(2.6463)	(3.3455)
B^i_{TT}	0.0086	0.0166	0.0091
	(3.1509)	(1.2962)	(4.3592)

Parameter	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
A^i_O	0.7122	-0.9709	-0.4396
	(2.3944)	(-0.1002)	(-2.0782)
A^i_K	2.7743	3.5637	1.1400
	(4.2707)	(0.1997)	(1.7526)
A^i_L	0.1717	0.0372	0.1748
	(1.9287)	(1.0917)	(15.9541)
A^i_M	0.4603	1.1499	0.5299
	(7.2247)	(8.9050)	(18.2730)
A^i_T	-0.1367	-0.1881	0.0362
	(-2.8612)	(-0.1056)	(0.8222)
B^i_{MM}	-0.0684	-0.1167	0.0072
	(-2.8432)	(-4.5641)	(0.3202)
B^i_{MK}	-0.0444	0.5939	-0.0348
	(-3.0700)	(4.1830)	(-1.5344)
B^i_{ML}	-0.0366	0.0117	0.0040
	(-1.3908)	(1.8211)	(0.4664)
B^i_{MT}	0.0196	-0.0363	0.0062
	(3.3713)	(-3.1115)	(2.4574)
B^i_{KK}	3.3800	5.7392	1.9861
	(4.7060)	(0.3453)	(2.1496)
B^i_{KL}	-0.0005	-0.1030	0.0599
	(-0.0312)	(-2.9371)	(6.0519)
B^i_{KT}	-0.2295	-0.6081	-0.1050
	(-4.2754)	(-0.3687)	(-1.5776)
B^i_{LL}	0.0286	0.0206	-0.0505
	(0.6365)	(2.1519)	(-9.5764)
B^i_{LT}	0.0012	0.0047	0.0010
	(0.1564)	(1.5244)	(1.0634)
B^i_{TT}	0.0132	0.0488	0.0007
	(3.4557)	(0.2975)	(0.1553)

Parameter	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
A^i_0	-2.3245	4.7892	-0.5122
	(-0.6829)	(1.0642)	(-2.6180)
A^i_K	-1.2568	6.5527	0.2450
	(-0.2275)	(1.03050	(1.0804)
A^i_L	0.0551	0.0296	0.1263
	(2.2042)	(1.5838)	(5.5474)
A^i_M	0.6853	0.7114	0.5934
	(8.5758)	(12.4465)	(10.8270)
A^i_T	0.3343	-0.8518	0.0773
	(0.5292)	(-1.0227)	(2.5846)
B^i_{MM}	0.1311	-0.2288	0.0241
	(5.7411)	(-5.0483)	(0.5659)
B^i_{MK}	-0.2879	0.3469	-0.0405
	(-4.4301)	(4.2438)	(-1.3162)
B^i_{ML}	-0.0274	0.0343	-0.0118
	(-4.2335)	(2.2830)	(-0.7866)
B^i_{MT}	0.0118	0.0062	0.0053
	(1.6270)	(1.1785)	(1.0727)
B^i_{KK}	0.6157	3.2345	0.1562
	(0.1371)	(0.7124)	(1.1349)
B^i_{KL}	0.0508	-0.0508	0.0378
	(2.4540)	(-1.9538)	(2.8924)
B^i_{KT}	0.0713	-0.5508	0.0121
	(0.1390)	(-0.9325)	(0.6213)
B^i_{LL}	-0.0160	-0.0475	-0.0313
	(-4.4314)	(-6.2454)	(-2.4868)
B^i_{LT}	0.0021	0.0051	0.0033
	(0.9246)	(2.9438)	(1.6095)
B^i_{TT}	-0.0227	0.0754	-0.0056
	(-0.3886)	(0.9782)	(-2.3738)

Parameter	Industry The whole manucturing
A^i_0	17.0329
	(2.4388)
A^i_K	25.3316
	(2.6296)
A^i_L	0.1317
	(8.2338)
A^i_M	0.7122
	(18.2734)
A^i_T	-3.2948
	(-2.5341)
B^i_{MM}	0.0629
	(5.3928)
B^i_{MK}	-0.0042
	(-0.1500)
B^i_{ML}	-0.0462
	(-6.3483)
B^i_{MT}	-0.0033
	(-0.9217)
B^i_{KK}	18.1481
	(2.7252)
B^i_{KL}	0.0341
	(2.9537)
B^i_{KT}	-2.4091
	(-2.6831)
B^i_{LL}	0.0241
	(2.4017)
B^i_{LT}	0.0005
	(0.3495)
B^i_{TT}	0.3173
	(2.6222)

Table II-17. Parameter Estimates under Hicks Neutrality estimated by SUR

Parameter	Industry		
	1. Food, beverages & tobacco	2. Textiles & leather	3. Lumber & wood products
A^i_O	-0.7129	0.4053	-0.0412
	(-3.3885)	(0.7127)	(-0.2242)
A^i_K	0.4273	0.4639	0.2959
	(2.5857)	(1.6515)	(1.7647)
A^i_L	0.0769	0.1503	0.1470
	(78.2363)	(62.9417)	(46.0974)
A^i_M	0.5363	0.6987	0.7392
	(240.8526)	(121.7912)	(157.6715)
A^i_T	0.0818	-0.0638	0.0029
	(3.1379)	(-0.8286)	(0.1087)
B^i_{MM}	-0.0537	-0.4361	0.1175
	(-3.9243)	(-1.3527)	(6.9571)
B^i_{MK}	0.0644	0.1189	-0.1776
	(3.4499)	(1.9833)	(-4.4602)
B^i_{ML}	0.0184	0.0119	0.0071
	(1.3578)	(1.0399)	(0.8446)
B^i_{MT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{KK}	0.8892	-0.3515	0.2830
	(5.5219)	(-1.0206)	(1.2626)
B^i_{KL}	-0.0332	-0.0284	-0.0378
	(-4.0200)	(-1.2118)	(-1.9166)
B^i_{KT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.00000
B^i_{LL}	-0.0155	-0.0090	0.0155
	(-0.9153)	(-0.8979)	(1.5315)
B^i_{LT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{TT}	-0.0031	0.0046	0.0000
	(-2.3447)	(1.0443)	(0.0176)

Parameter	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
A^i_O	-0.2193	-4.6908	-0.6739
	(-1.5698)	(-2.3584)	(-11.7489)
A^i_K	0.1916	-2.6161	0.1161
	(1.5034)	(-2.7570)	(2.1955)
A^i_L	0.1866	0.0905	0.1865
	(127.7736)	(100.6596)	(115.2388)
A^i_M	0.6762	0.7477	0.6049
	(504.2635)	(161.2397)	(140.6274)
A^i_T	0.0254	0.5387	0.0893
	(1.5023)	(2.0361)	(10.1006)
B^i_{MM}	0.0182	-0.0618	0.0450
	(1.6733)	(-2.5004)	(2.7452)
B^i_{MK}	0.0037	0.1513	-0.0473
	(0.3494)	(3.4117)	(-1.7149)
B^i_{ML}	0.0029	0.0016	0.0114
	(0.1995)	(0.4001)	(2.0312)
B^i_{MT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{KK}	0.3846	0.7934	0.5594
	(5.0331	(0.5179)	(5.2277)
B^i_{KL}	0.0085	-0.0350	0.0615
	(0.6713)	(-3.5749)	(5.7887)
B^i_{KT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{LL}	-0.0141	0.0182	-0.0524
	(-0.6230)	(4.7095)	(-9.0022)
B^i_{LT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{TT}	-0.0010	-0.0219	-0.0051
	(-1.4276)	-1.3806	(-7.8881)

Parameter	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
A^i_0	-1.7002	0.7420	-0.2965
	(-7.1778)	(1.1920)	(-2.2594)
A^i_K	-0.5407	0.6089	0.3891
	(-4.5710)	(2.6513)	(4.9595)
A^i_L	0.0784	0.0842	0.1623
	(43.5937)	(71.2490)	(117.2134)
A^i_M	0.8166	0.7794	0.6513
	(132.2045)	(287.0511)	(141.3076)
A^i_T	0.2133	-0.1018	0.0400
	(6.8164)	(-1.1924)	(2.6083)
B^i_{MM}	0.1513	-0.2317	0.0503
	(6.4952)	(-5.0828)	(2.9223)
B^i_{MK}	-0.2304	0.4097	-0.0643
	(-5.1301)	(5.8614)	(-2.6865)
B^i_{ML}	-0.0248	0.0273	0.0054
	(-3.9509)	(1.6370)	(0.7197)
B^i_{MT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{KK}	1.0740	-1.1519	0.2991
	(7.1246)	(-3.0364)	(6.8691)
B^i_{KL}	0.0641	-0.0104	0.0184
	(4.8792)	(-0.4485)	(2.7024)
B^i_{KT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{LL}	-0.0161	-0.0387	-0.0181
	(-4.4015)	(-3.5523)	(-1.9973)
B^i_{LT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{TT}	-0.0110	0.0060	-0.0024
	(-5.9075)	(1.1052)	(-3.7716)

Parameter	Industry The whole manucturing
A^i_0	-1.8557
	(-3.1549)
A^i_K	-0.5911
	(-2.4368)
A^i_L	0.1373
	(200.9108)
A^i_M	0.6763
	(408.4364)
A^i_T	0.2159
	(2.7489)
B^i_{MM}	0.0583
	(4.9245)
B^i_{MK}	-0.0254
	(-1.6531)
B^i_{ML}	-0.0425
	(-5.5584)
B^i_{MT}	0.0000
	(0.0000)
B^i_{KK}	0.3710
	(1.3484)
B^i_{KL}	0.0356
	(5.8370)
B^i_{KT}	0.0000
	(0.0000)
B^i_{LL}	0.0202
	(1.9393)
B^i_{LT}	0.0000
	(0.0000)
B^i_{TT}	-0.8701
	(-1.8609)

Table II-18 Parameter Estimates under Existence of Value-added Function by SUR

Parameter	Industry		
	1.Food, beverages & tobacco	2.Textiles & leather	3.Lumber & wood products
A^i_O	-0.0130	1.1262	0.7974
	(-0.0490)	(1.2333)	(4.0620)
A^i_K	2.7245	2.0764	3.2894
	(4.4672)	(1.2420)	(5.8881)
A^i_L	0.0367	0.1123	0.1265
	(2.4487)	(7.7982)	(15.3152)
A^i_M	0.5300	0.6988	0.7290
	(320.6497)	(114.2106)	(140.7321)
A^i_T	-0.0334	-0.1939	-0.1321
	(-0.8469)	(-1.2742)	(-4.2740)
B^i_{MM}	-0.0119	0.0277	0.0443
	(-6.2149)	(4.9763)	(7.8478)
B^i_{MK}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{ML}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{MT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{KK}	4.2546	1.5209	4.2204
	(5.1309)	(0.8704)	(5.2359)
B^i_{KL}	-0.0213	-0.0419	-0.0329
	(-4.0392)	(-2.2854)	(-3.7385)
B^i_{KT}	-0.1924	-0.1455	-0.2385
	(-3.9029)	(-0.9562)	(-5.2360)
B^i_{LL}	-0.0335	-0.0072	-0.0082
	(-2.4327)	(-0.8193)	(-0.7492)
B^i_{LT}	0.0036	0.0032	0.0019
	(2.7576)	(2.6610)	(2.5170)
B^i_{TT}	0.0064	0.0162	0.0107
	(2.2043)	(1.2660)	(4.5848)

Parameter	Industry		
	4. Paper, printing & publishing	5. Chemicals & chemical products	6. Nonmetalic mineral products
A^i_O	1.0443	-10.9304	-0.3723
	(3.4550)	(-0.9149)	(-1.8517)
A^i_K	2.9868	-13.7603	1.2047
	(4.5958)	(-0.6234)	(1.9235)
A^i_L	0.2866	0.0700	0.1590
	(6.5122)	(3.9820)	(35.1577)
A^i_M	0.6759	0.7421	0.5991
	(633.7905)	(160.3708)	(198.4257)
A^i_T	-0.1934	1.6315	0.0217
	(-3.9767)	(0.7416)	(0.5177)
B^i_{MM}	0.0228	0.0151	0.0337
	(17.4535)	(4.1093)	(10.9240)
B^i_{MK}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{ML}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{MT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{KK}	3.5129	-8.9947	2.0448
	(5.0011)	(-0.4357)	(2.2953)
B^i_{KL}	0.0149	-0.0504	0.0489
	(1.3369)	(-4.4702)	(7.1016)
B^i_{KT}	-0.2430	0.9708	-0.1138
	(-4.6055)	(0.4756)	(-1.7758)
B^i_{LL}	0.0691	0.0191	-0.0503
	(1.9136)	(2.3628)	(-13.6354)
B^i_{LT}	-0.0092	0.0018	0.0024
	(-2.2726)	(1.1251)	(6.5068)
B^i_{TT}	0.0179	-0.1167	0.0022
	(4.6160)	(-0.5756)	(0.5116)

Parameter	Industry		
	7. Primary metal manufacturing	8. Metal products & machinery	9. Miscellaneous manufacturing
A^i_O	-0.9379	3.4018	-0.3520
	(-0.2989)	(0.7733)	(-1.8249)
A^i_K	0.4286	4.3618	0.3345
	(0.0842)	(0.7018)	(1.5061)
A^i_L	0.0480	0.0199	0.1377
	(1.9023)	(1.3434)	(12.9115)
A^i_M	0.7823	0.7779	0.6607
	(206.2660)	(190.7199)	(179.6206)
A^i_T	0.0925	-0.5869	0.0493
	(0.1589)	(-0.7208)	(1.6874)
B^i_{MM}	0.0143	0.0130	0.0151
	(5.3407)	(4.5724)	(5.2779)
B^i_{MK}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{ML}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{MT}	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
B^i_{KK}	1.1643	2.1759	0.1685
	(0.2816)	(0.4906)	(1.2410)
B^i_{KL}	-0.0117	-0.0041	0.0228
	(-0.5560)	(-0.3223)	(3.5170)
B^i_{KT}	-0.0675	-0.3414	0.0034
	(-0.1428)	(-0.5915)	(0.1781)
B^i_{LL}	-0.0178	-0.0408	-0.0276
	(-4.7122)	(-6.3158)	(-2.8682)
B^i_{LT}	0.0033	0.0060	0.0022
	(1.4291)	(4.3641)	(2.2368)
B^i_{TT}	-0.0018	0.0501	-0.0032
	(-0.0339)	(0.6648)	(-1.4071)

Parameter	Industry The whole manucturing
A^i_O	8.7194
	(1.0731)
A^i_K	14.2764
	(1.2730)
A^i_L	0.1463
	(12.5811)
A^i_M	0.6759
	(424.7895)
A^i_T	-1.7624
	(-1.1646)
B^i_{MM}	0.0175
	(12.2801)
B^i_{MK}	0.0000
	(0.0000)
B^i_{ML}	0.0000
	(0.0000)
B^i_{MT}	0.0000
	(0.0000)
B^i_{KK}	10.8000
	(1.3925)
B^i_{KL}	0.0214
	(2.5933)
B^i_{KT}	-1.3909
	(-1.3304)
B^i_{LL}	-0.0325
	(-7.1107)
B^i_{LT}	-0.0008
	(-0.7931)
B^i_{TT}	0.1761
	(1.2506)

Table III-8. Sources of Sectoral Output Growth: 19 Sectors Model (in percent) 1975-1978

Industry	Δ X			
	DD	EE	IS	IO
1. Agri, Forest & fish	77.4	9.9	14.0	-1.2
2. Mining	25.9	14.8	77.4	-18.2
3. Food & beverages	117.9	4.2	1.7	-20.2
4. Textiles & leather	39.7	59.1	0.3	0.8
5. Lumber & wood prod	62.2	42.6	-1.4	-3.4
6. Paper,print & publ	109.4	30.1	3.0	-42.6
7. Chems & chem prods	93.3	57.4	-0.4	-50.3
8. Nonmetal min prods	117.5	35.3	-7.5	-45.2
9. Prim metal manufac	113.0	104.7	-20.7	-97.0
10. Metal prods & mach	55.4	41.8	2.3	0.4
11. Misc manufacturing	29.5	75.3	-4.5	-0.3
12. Construction	102.2	0.7	-0.0	-2.8
13. Elec, gas &wtr serv	89.7	34.5	4.8	-28.9
14. Wholesale & retail	72.6	30.4	0.3	-3.3
15. Transp,wrhs & comm	58.3	41.8	-3.8	3.7
16. Fin,ins & real est	76.7	12.0	1.5	9.8
17. Publ admin & defen	100.0	0.0	0.0	0.0
18. Restrnt & hotl,etc	91.5	6.0	-0.6	3.1
19. Dummy sector	85.9	37.5	-6.1	-17.4

Table III-9. Sources of Sectoral Output Growth: 19 Sectors Model (in percent) 1978-1980

Industry	Δ X			
	DD	EE	IS	IO
1. Agri,forest & fish	187.8	9.6	18.3	-115.7
2. Mining	12.2	-19.3	423.5	-316.4
3. Food & beverages	70.7	-0.6	8.3	21.6
4. Textiles & leather	-699.0	610.6	363.4	-175.0
5. Lumber & wood prod	-22.3	131.1	12.4	-21.2
6. Paper,print & publ	12.1	8.1	7.0	72.9
7. Chems & chem prods	-1.9	12.8	20.3	68.8
8. Nonmetal min prods	16.5	9.0	11.9	62.6
9. Prim metal manufac	-8.4	33.6	41.0	33.5
10. Metal prods & mach	-203.8	705.0	142.8	153.5
11. Misc manufacturing	-71.9	-390.1	126.1	435.9
12. Construction	59.2	1.2	1.0	38.6
13. Elec,gas &wtr serv	10.6	7.2	7.9	74.3
14. Wholesale & retail	355.6	164.8	93.3	-513.7
15. Transp,wrhs & comm	35.0	50.6	-13.8	28.2
16. Fin,ins & real est	-5.7	4.2	8.2	93.3
17. Publ admin & defen	99.8	0.5	-3.0	2.7
18. Restrnt & hotl,etc	5.6	2.9	-3.4	94.9
19. Dummy sector	6.7	-11.8	33.3	71.4

Table III-10. Sources of Sectoral Output Growth: 19 Sector Model (in percent) 1980-1983

Industry	Δ X			
	DD	EE	IS	IO
1. Agri,forest & fish	100.8	6.4	27.9	-35.1
2. Mining	85.8	177.6	41.6	-205.0
3. Food & beverages	123.6	13.5	32.7	-69.7
4. Textiles & leather	-60.1	229.7	-87.0	17.5
5. Lumber & wood prod	567.9	-316.8	-32.4	-118.7
6. Paper,print & publ	-1094.6	-304.5	-557.6	2056.7
7. Chems & chem prods	144.0	118.9	-15.7	-147.2
8. Nonmetal min prods	233.2	57.8	-30.9	-160.1
9. Prim metal manufac	-7.2	90.3	45.7	-28.8
10. Metal prods & mach	28.4	48.9	19.4	3.2
11. Misc manufacturing	44.1	68.3	-2.8	-9.5
12. Construction	104.3	4.5	0.3	-9.2
13. Elec,gas &wtr serv	53.8	28.5	4.4	13.3
14. Wholesale & retail	39.2	91.6	-0.4	-30.4
15. Transp,wrhs & comm	39.7	42.3	9.7	8.2
16. Fin,ins & real est	171.4	31.0	7.5	-110.0
17. Publ admin & defen	98.3	1.4	1.1	-0.8
18. Restrnt & hotl,etc	98.3	11.1	-0.8	-8.6
19. Dummy sector	85.7	67.9	18.9	-72.5

Table III-11. Sources of Sectoral Output Growth:
19 Sector Model (in percent)
1983-1985

Industry	Δ X			
	DD	EE	IS	IO
1. Agri,forest & fish	66.9	9.6	17.0	6.4
2. Mining	100.4	65.8	37.3	-103.5
3. Food & beverages	73.3	11.1	10.5	4.7
4. Textiles & leather	5.5	63.0	4.9	26.6
5. Lumber & wood prod	247.9	22.4	-32.5	-137.8
6. Paper,print & publ	43.7	25.7	-5.5	36.1
7. Chems & chem prods	48.5	73.8	-7.1	-15.2
8. Nonmetal min prods	79.1	8.1	0.0	12.7
9. Prim metal manufac	699.5	458.8	66.8	-1125.2
10. Metal prods & mach	34.3	47.2	11.6	6.8
11. Misc manufacturing	17.1	116.9	1.9	-36.0
12. Construction	88.2	4.1	0.1	7.5
13. Elec,gas &wtr serv	143.5	66.5	4.6	-114.6
14. Wholesale & retail	108.3	22.0	5.8	-36.1
15. Transp,wrhs & comm	113.9	26.7	-6.4	-34.3
16. Fin,ins & real est	41.8	7.8	-1.0	51.4
17. Publ admin & defen	101.0	-0.3	8.5	-9.2
18. Restrnt & hotl,etc	318.3	25.0	-5.9	-237.5
19. Dummy sector	73.6	14.9	-4.2	15.6

Table III-12. Sources of Sectoral Output Growth:
19 Sector Model (in percent)
1975-1978

Industry	δ X			
	DD	EE	IS	IO
1. Agri,forest & fish	23.8	-11.8	90.8	-2.8
2. Mining	6.5	1.1	113.7	-21.3
3. Food & beverages	-203.1	113.8	14.6	174.7
4. Textiles & leather	160.2	97.6	-24.4	-133.4
5. Lumber & wood prod	77.2	31.1	-2.7	-5.7
6. Paper,print & publ	-2302.7	-125.9	-279.7	2808.3
7. Chems & chem prods	-139.8	-134.0	1.2	372.6
8. Nonmetal min prods	193.2	59.3	-25.6	-126.9
9. Prim metal manufac	183.7	180.7	-45.5	-218.8
10. Metal prods & mach	50.6	45.7	2.9	0.9
11. Misc manufacturing	25.4	80.0	-5.2	-0.2
12. Construction	103.2	0.1	-0.0	-3.3
13. Elec,gas &wtr serv	105.4	71.9	34.1	-111.4
14. Wholesale & retail	13.8	79.2	3.5	3.5
15. Transp,wrhs & comm	26.8	70.0	-12.1	15.3
16. Fin,ins & real est	67.6	10.0	2.8	19.6
17. Publ admin & defen	100.0	0.0	0.0	-0.0
18. Restrnt & hotl,etc	88.4	4.4	-1.1	8.3
19. Dummy sector	161.4	68.4	-50.8	-79.1

Table III-13. Sources of Sectoral Output Growth: 19 Sector Model (in percent) 1978-1980

Industry	δ X			
	DD	EE	IS	IO
1. Agri,forest & fish	123.4	5.2	21.9	-50.6
2. Mining	-4.4	137.5	-1296.5	1263.4
3. Food & beverages	75.0	-0.2	5.1	20.0
4. Textiles & leather	-51.8	131.6	42.1	-21.9
5. Lumber & wood prod	-60.4	194.6	17.0	-51.1
6. Paper,print & publ	17.0	10.2	6.5	66.4
7. Chems & chem prods	2.0	16.7	17.2	64.1
8. Nonmetal min prods	23.1	11.5	10.8	54.6
9. Prim metal manufac	-7.0	40.7	43.4	22.9
10. Metal prods & mach	-168.7	29.0	151.7	88.0
11. Misc manufacturing	-19.9	-170.7	51.1	239.5
12. Construction	71.9	1.4	0.9	25.7
13. elec,gas &wtr serv	15.3	9.2	7.8	67.7
14. Wholesale & retail	120.2	50.9	18.2	-89.4
15. Transp,wrhs & comm	38.8	51.0	18.2	-89.4
16. Fin,ins & real estm	1.2	5.9	7.2	85.7
17. Publ admin & defen	98.6	0.5	-1.4	2.2
18. Restrnt & hotl,etc	21.2	4.1	-2.7	77.3
19. Dummy sector	20.7	-7.0	33.4	52.9

Table III-14. Sources of Sectoral Output Growth: 19 Sector Model (in percent) 1980-1983

Industry	δ X			
	DD	EE	IS	IO
1. Agri,forest & fish	16.0	55.6	-116.0	144.4
2. Mining	52.8	6.5	-10.6	51.3
3. Food & beverages	80.9	5.6	-13.3	26.8
4. Textiles & leather	60.3	14.1	30.6	-5.0
5. Lumber & wood prod	-51.5	129.7	7.9	13.9
6. Paper,print & publ	8.1	5.8	-33.0	119.1
7. Chems & chem prods	7.1	-13.1	13.3	92.7
8. Nonmetal min prods	6.4	12.2	13.7	67.7
9. Prim metal manufac	273.4	-87.5	-187.0	101.1
10. Metal prods & mach	-0.0	60.8	34.4	4.8
11. Misc manufacturing	118.6	146.0	-36.7	-128.0
12. Construction	212.7	56.9	5.2	-174.7
13. Elec,gas &wtr serv	-2.3	23.7	13.8	64.8
14. Wholesale & retail	97.6	-15.0	2.3	15.1
15. Transp,wrhs & comm	-70.8	55.8	55.5	59.5
16. Fin,ins & real est	-32.2	-2.2	-8.6	142.9
17. Publ admin & defen	83.1	11.9	13.2	-8.3
18. Restrnt & hotl,etc	127.7	24.5	-4.5	-47.7
19. Dummy sector	51.0	-53.2	-32.4	134.6

Table III-15. Sources of Sectoral Output Growth: 19 Sector Model (in percent) 1983-1985

Industry	δ X			
	DD	EE	IS	IO
1. Agri,forest & fish	218.4	45.1	-89.9	-28.2
2. Mining	98.8	42.6	81.3	-221.2
3. Food & beverages	253.3	-3.8	-76.1	-21.4
4. Textiles & leather	-18.5	19.7	5.7	31.5
5. Lumber & wood prod	-17.1	13.4	9.5	35.2
6. Paper,print & publ	-50.1	23.1	-24.4	52.3
7. Chems & chem prods	-28.2	59.9	-14.8	-35.7
8. Nonmetal min prods	26.6	-67.6	0.6	46.0
9. Prim metal manufac	520.1	-142.9	83.3	-1439.0
10. Metal prods & mach	-1.2	16.3	10.6	5.6
11. Misc manufacturing	-19.4	66.1	2.7	-43.5
12. Construction	-64.6	15.4	2.4	82.8
13. ELec,gas &wtr serv	-44.6	-47.4	-21.5	566.9
14. Wholesale & retail	92.9	-3.7	9.9	-64.4
15. Transp,wrhs & comm	47.3	-129.2	-18.2	-99.1
16. Fin,ins & real est	22.5	3.3	-0.5	64.9
17. Publ admin & defen	101.3	1.0	-6.5	6.7
18. Restrnt & hotl,etc	-68.9	-7.6	5.0	195.1
19. Dummy sector	20.2	-25.3	-6.5	17.8

REFERENCES

Adelman, Irma. 1984. Beyond Export-Led Growth. World Development 12: 937-949.

Amemiya, Takeshi. 1977. The Maximum Likelihood and the Nonlinear Three-stage Least Squares Estimatir in the General Nonlinear Simultaneous Equation Model. Econometrica 45: 955-968.

Balassa, Bela. 1978. Exports and Economic Growth: Further Evidence. Journal of Development Economics 5: 181-189.

The Bank of Korea. Economic Statistics Yearbook (various issues) Seoul, Korea.

_____. Financial Statements Analysis (various issues) Seoul, Korea.

_____. Input-Output Tables of Korea. (1975,1978,1980,1983,1985). Seoul, Korea.

Berndt, E. R., and L. R. Christensen. 1973. The Translog Function and the Substitution of Equipment, Structures, and Labor in U.S. Manufacturing 1929-68. Journal of Econometrics 1: 81-114.

Berndt E. K., B. H. Hall, R. E. Hall, and J. A. Hausman. 1974. Estimation and Inference in Nonlinear Structural Models. Annals of Economic and Social Measurement 3/4 : 653-665.

Binswanger, Hans P. 1974. The Measurement of Technical Change Biases with many Factors of Production. American Economic Review 64: 964-976.

_____. 1974. A Microeconomic Approach to Induced Innovation. Economic Journal 84: 940-976.

_____. 1978. Issues in Modeling induced technical Change. In Induced Innovation, ed. Hans P. Binswanger and Vernon W. Ruttan. Baltimore: Johns Hopkins University Press.

Blackorby, Charles, Daniel Primont, and R. Robert Russel. 1978. Duality, Separability, and functional Structure: Theory and Economic Applications. New York: North-Holland.

Chenery, H. B., S. Robinson, and M. Syrquin.1986. Industrialization and Growth: A Comparative Study. Oxford: Oxford University Press.

Chenery, H. B., S. Shishido, and T. Watanabe. #1962. The Pattern of Japanese Growth, 1914-1954. Econometrica vol:30.

Chenery, H. B., and L. Taylor.1968. Development Patterns: Among Countries and Over Times. The Review of Economics and Statistics 50: 391-416.

Christensen, L. R., and D. Cummings. 1981. Real Products, Real Factor Inputs and Productivity in the Republic of Korea, 1960-1973. Journal of Development Economics 8: 285-302.

_____, and W. H. Green. 1976. Economies of Scale in U.S. Electric Power Generation. Journal of Political Economy 84: 655-676.

_____, D. W. Jorgenson, and L. J. Lau. 1971. Conjugate duality and the transcendental logarithmic production function. Econometrica 39: 255-256.

_____. 1973. Transcendental logarithmic production frontiers. Review of Econometrics and Statistics 55: 28-45.

Corbo, V., A. O. Krueger, and F. Ossa.1985. Export Oriented Development Strategies: The Success of Five Newly Industrializing Countries.Boulder, Colorado: Westview Press, Inc., Ch.4.

Denny, M., and M. Fuss. 1977. The Use of Approximation Analysis to Test for Separability and the Existence of Consistent Aggregate. American Economic Review 67: 404-418.

Dervis, K., J. D. Melo, and S. Robinson.1982. General Equilibrium Models for Development Policy. Cambridge: Cambridge University Press.

Dervis, K., and P. A. Petri.1987. The Macroeconomics of Successful Development: What are the Lessons? Macroeconomics Annual. Cambridge. Massachusetts. MIT Press. pp. 211-254.

Dornbush, R., and Y. Ch. Park.1987. Korean Growth Policy. Brookings Papers on Economic Activity 2: 389-454.

Economics Planning Board. Report in Mining and Manufacturing Survey (various issues). Seoul, Korea.

_____. 1985. Annual Report on the Economically Active Population Survey Seoul, Korea.

Frank, C. R., K. S. Kim, and L. E. Westphal. 1975. Foreign Trade Regimes and Economic Development: South Korea. New York: Columbia University Press, Ch. 6.

Gallant A. R., and D. W. Jorgenson. 1980. Statistical Inference for a System of Simultaneous, Nonlinear, Implicit Equations in the context of Instrumental Variable Estimation. Journal of Econometrics 11: 275-302.

Grabill, Franklin A. #1969. Introduction to Matrices with Applications in Statistics.Belmont, California: Wadsworth Publishing Company.

Hicks, John R. 1946. Value and Capital. Oxford: Oxford University Press.

International Monetary Fund. 1986. International Financial Statistics. Washington, D.C.

Jorgenson, Dale W., Frank M Gollop, and Barbara M. Fraumeni. 1987. Productivity and U.S. Economic Growth. Cambridge: Harvard University Press.

Jorgenson, Dale W., and J. Laffont. 1974. Efficient Estimation of Nonlinear Simultaneous Equations with Additive Disturbances. Annals of Economic and Social Measurement 3/4: 615-640.

Jorgenson, Dale W., and Lawrence J. Lau. 1974. Duality and differentiability in production. Journal of Economic Theory 9: 23-42.

_____. 1975. The Structure of Consumer Preferences. Annals of Economic and Social Measurement. 4/1: 49-101.

Kavoussi, and Rostam M. #1984. Export Expansion and Economic Growth. Journal of Development Economics 14: 241-250

_____. 1985. International Trade and Economic Development: The Recent Experience of Developing Countries. Journal of Developing Areas 19: 379-392.

Kendrick, John W., and Elliot S. Grossman. 1980. Productivity in the United States: Trends and Cycles. Baltimore: Johns Hopkins University Press.

Kim, K. S., and S. Y. Park. 1989. The Analysis of the Productivity Change and the Sources of Productivity in Korean Manufacturing. Seoul: Korea Institute for Economics & Technology.

Kim, K. S., and M. Roemer. 1981. Growth and Structural Transformation Studies in the Modernization of The Republic of Korea (1964-1975). Cambridge: Harvard University Press, Ch. 5.

Krueger, A. O., H. B. Larry, T. Monson, and N. Akrasanee. 1981. Trade and Employment in Developing Countries. Chicago: National Bureau of Economic Research, The University of Chicago Press.

Krueger, Anne O. 1983. The Effects of Trade Strategy on Growth. Finance and Development vol: 20-22.

_____. 1978. Foreign Trade Regimes and economic Developments: Attempts and Consequences. Cambridge. Massachusetts. MIT Press.

Krugman, P. R, and M. Obsfeld. 1988. International Economics. Glenview, Illinois: Scott, Foresman and Company.

Kwon, J. K., and M. Williams. 1982. The Structure of Production in South Korea's Manufacturing Sector. Journal of Development Economics 11: 215-226.

Lau, Lawrence J. 1978. Testing and Imposing Monotonicity, Convexity, and Quasi-Convexity Constraints. In Economics: A Dual Approach to Theory and Applications, ed. Melvyn Fuss and Daniel McFadden. Vol. 1. Amsterdam: North-Holland.

Lewis, W. Arthur. 1980. The Slowing down of the Engine of Growth. The American Economic Review vol: 555-564.

Nadiri, M. Ishaq. 1970. Some Approaches to the Theory and Measurement of Total Factor Productivity: A Survey. Journal of Economic Literature 8-4: 1137-1377.

Norsworthy, J. R. and D. H. Malmquist. 1983. Input Measurement and Productivity Growth in Japanese and U.S. Manufacturing. American Economic Review 73: 947-1067.

Pyo, H. K. 1984. Elasticities of Substitution and Technical Progress in a Developing Economy: The Case of Korea, 1963-81. Paper presented at 1983 Korean Economic Association Meeting. Seoul, Korea.

Rhee, S. Y. 1982. Total Factor Productivity Analysis: A Disaggregated Study if the Korean Mining and Manufacturing Sectors With Explicit Consideration of Intermediate Inputs.(Mimeograph). Korea Development Institute. Seoul, Korea.

Samuelson, Paul A. 1973. Relative shares and elasticities simplified: Comment. American Economic Review 63: 770-771.

Sono M. 1961. The effect of price changes on the demand and supply of separable goods. International Economic Review 2: 239-271.

Westphal, Larry E.. 1978. The Republic of Korea's Experience with Export-Led Industrial Development. World Development 6-3: 347-382.

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